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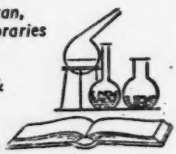

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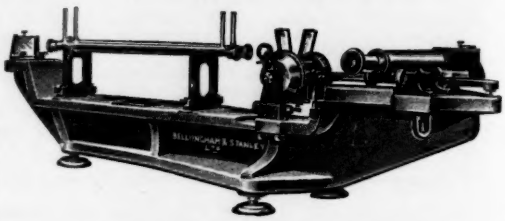

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THE BROADENING OF UNIVERSITY EDUCATION

AN important chapter in the recent report of the Appleton Committee on the supply of teachers of mathematics and science in Scotland discusses some questions regarding the universities which were raised in the memoranda submitted to the Committee. The three most important of these related to entrance qualifications, to the content of honours degree courses and to the extent to which graduates stay on at the universities to undertake research immediately after taking their first degree. On the last question, the Committee merely observes that conflicting views are held, and it enters no further on a difficult and debatable subject than to suggest that university professors, in considering whether or not to admit students to research courses, should have regard to the urgent national need for scientists in other capacities in the various professions and in industry.

Beyond that, it is clear that there is room for some fresh thinking as to the place of research in university life, or even as to our conception of what we mean by the advancement of knowledge. It is not to be confused with the accumulation of fresh facts in a restricted field; and the Appleton Committee shows that it is aware of this when, discussing the content of honours degree courses, it refers to the real and widespread desire for a less highly specialized honours course which would provide a better all-round knowledge of the subject in question and be concerned less with the immediate introduction to a limited field of research. The Appleton Committee reached no firm conclusion. It regards the difficulty of an honours degree course as its prime characteristic, not its concentration on a limited field on the frontier of knowledge, and suggests as worthy of consideration the institution of an honours B.Sc. degree in two branches of science, less specialized than the present degree in one subject, and yet less general than the so-called general honours course.

Such proposals, however, infringe on the third question—that of university entrance requirements. Here the Appleton Committee is concerned chiefly that lack of opportunity to study, or inability in, a foreign language should not by itself be allowed to debar a person from entering a university to study mathematics, science or technology, if he is otherwise well qualified to do so. It suggests that this is a matter which the universities in Britain might appropriately consider, bearing in mind that the nation requires all the skilled scientists and technologists it can produce.

This difficulty is sometimes due to a false choice made by students—for lack of guidance or in spite of it—at some stage in their career. There will always be such students, and for this reason the Committee suggests that the universities should consider revision of their faculty and class requirements so that as many students as possible can have the opportunity of taking scientific courses. A related problem is that of the later development of latent scientific ability, and there can be no question that easier transfer between university departments would be in the national interest and not merely at the present time as a means of increasing the number of science students.

University entrance is, however, equally of importance in relation to general education. In a recent conference, "Education in a Changing World", at the Manchester Training College, the chairman, Mr. F. Heywood, urged that there should be no narrowing of the curriculum at schools and universities and claimed that industry needs graduates of broad general education rather than specialists. Dr. P. F. R. Venables said that education should train for flexibility, and that there is need for a broad training in other subjects besides technology and science. Prof. F. A. Vick likewise said that the university courses of a student of physics should be a fusion of thoroughness and breadth.

What needs to be remembered above all is that the problem of finding sufficient science teachers for schools in Britain can no more be discussed in isolation than the expansion of higher technological education or of technical education. All such specific problems ultimately must be considered in relation to the educational policy of the country as a whole. There must be some clear understanding of the purpose of education before we can wisely determine the resources which can be allocated to meet particular needs and purposes. Nor will the priorities be wisely assigned without an understanding that goes far outside the ranks of the educationist and embraces not simply the administrator and the politician but also the citizens in general whose sons and daughters are to be educated. Well did Prof. W. R. Niblett write in his recent book, that one of the most urgent needs for education in Britain is a much more whole-hearted effort to secure closer understanding between home and school; but it is equally true that if the universities are to play their full part in educating men and women of quality and purpose, vision and intelligence, belief and will—if they are to release the powers of leadership in more people—it will be in large measure as the community itself understands and co-operates with the university.

Prof. Niblett here makes the point about co-operation which Dr. Margaret Read made so effectively in discussing education and social change before the British Association in Edinburgh four years ago. If the educational system of Britain is really to fit modern society and to meet its needs, it must be understood by the nation and approved to the extent required for such co-operation to be achieved. That is the first task in communication. It has to be remembered constantly that what is educationally desirable may be socially unacceptable; and again that what is socially desirable may be economically unattractive, or even if economically attractive it may be politically unfeasible.

Some of our difficulties arise because we have not met the challenge to fresh thinking which changed conditions have brought. The appeal which Lord Woolton and Sir John Stopford have recently launched to raise one million pounds over the next ten years to finance the building of halls of residence at the University of Manchester expresses, indeed, an attempt to meet two such challenges from changed conditions. Lord Woolton commended the appeal as an attempt to build a residential university which would more surely supply the leaders and teachers which we are failing to find in sufficient numbers, and he referred particularly to the value of residential colleges for the acquisition of that knowledge of how to live in a world where human relations are as important as intellectual capacity.

Halls of residence of themselves will not necessarily bridge the gulf unless their purpose is clearly understood and they receive the full support of the community. The two main challenges which they are intended to meet were clearly indicated by Sir John Stopford. First, there is that of specialization. We are in danger, he said, of becoming such isolated units as to produce a generation incapable of understanding education as it was understood by earlier generations. The danger was strikingly emphasized by Sir Walter Moberly in his book six years ago; but although in some universities, such as at Glasgow, something has been done to explore the problem, as Mr. J. F. Sleeman's article in the *Universities' Review* of February shows, very little effective action has been taken to break down the isolation.

Halls of residence will provide one opportunity, but we have still to ensure that it is used; that may well depend on the university staff and on the home as much as on the student. This is no less true of the second challenge. We are offering students to-day very good educational facilities; but it is not only at Manchester that too few are exposed to those broadening and cultural influences which full participation in a corporate life and extra-curricular activities can provide, or are learning to undertake responsibility, to find a real purpose in life, to acquire poise and to develop those qualities of character and personality which are essential for leadership. Moreover, we have to take due account of the fact that the striking changes in the social composition of the student body over the past few decades mean that an increasing proportion of undergraduates is drawn from homes without a tradition of study, and where the environment tends to stifle rather than foster character and culture. Nor can we disregard the possibility that such developments as television may be detrimental, rather than conducive, to learning and culture.

To check narrowness and excessive specialization, to encourage breadth and a balanced personality as well as a balanced mind, is not simply a matter of buildings or of grants to students at an appropriate level to encourage them to make use of such facilities; it is a matter of outlook and atmosphere also. Industry itself, for example, could attest the genuineness of its concern for more breadth and balance not only by financial contributions to the building and equipment of halls of residence in the civic universities, but still more by the attention it pays in recruitment to those who have used the opportunities of corporate and more spacious living which residence affords.

That would do much to counter the narrowing effect which home influence or close preoccupation with obtaining a degree may have; but university authorities could probably do even more by their policy in such matters as university entrance, general education or the transfer from one faculty to another. The more that is done to encourage and facilitate communication between one faculty or one specialism and another, the more fruitful are halls of residence and similar means likely to prove in enriching the life and outlook of the student. It should not be forgotten also that, as Dr. Eric Ashby has emphasized, halls of residence are not the only or even the most economic means of providing the stimulus desirable. With the right tactics and encouragement, student centres could provide valuable opportunities at much less cost, while it might equally be possible to organize a fuller use of existing halls of residence. If, for example, we fail to give those specializing in the arts an understanding of science and the scientific method at some stage of their education, failure of communication may well persist, and even in a residential college the arts student and the science student will be unable to take part effectively in those informal debates which go far to correct the defects of specialization.

This is the problem which demands first attention, and it should be noted that even at the staff-level Mr. Sleeman, in the article already noted, admits that real contact and understanding between colleagues in other departments is still difficult so far as deep professional interests are concerned. To remedy this would increase the adaptability of the arts graduate and also correct that danger of a specialized scientific education in Britain—neglect of the full study of man. It should be the first step to making possible that conversion of the arts graduate, through intensive one-year courses in the fundamentals of science, as a means of overcoming the shortage of science teachers, which Dr. B. V. Bowden, principal of the Manchester College of Technology, has suggested.

The solution, however, does not lie in adding fresh courses to the overloaded curriculum of the undergraduate. At that level, it is the way in which science is taught, for example, that matters. As Dr. Eric James has urged, science can be presented as an intellectual discipline in its own right, capable of developing all the breadth and human interest required and with due weight on the limitations as well as the potentialities of science. If this is to be done, however, and the arts student likewise to appreciate the significance of the scientific approach to knowledge and its place in the development of thought and culture, apart from its bearing on living in the modern world, the beginnings must be made in the schools—in the teaching of science in such a way and at such a level that its importance is grasped, as well as the openings and interest it

offers as a career, and in making it easier for pupils in the sixth forms to change to, or from, the science side if they wish.

Once again we come back to the critical importance of the science teacher, and a clear understanding of the exact function of the science teacher and his real contribution to the needs of the nation to-day would go far to overcome the difficulty of prestige which Prof. R. E. Peierls and Dr. James stressed as of particular importance in a discussion at the Home Universities Conference last December. If we could secure widespread recognition of the worth of the science teacher by the community generally, one major difficulty in securing enough teachers would be overcome; and at the same time something would have to be done to make science teaching itself more effective. When the teaching career is in itself highly regarded, men and women are both encouraged to give of their best in their teaching, and those efforts are likely to be more fruitful.

It is not, however, simply a matter of more generous support and understanding by the community in general. Special sections, as has already been indicated, bear particular responsibilities. More vision is essential on the part of some sections of the teaching profession itself, and less disposition to insist on uniformity instead of encouraging merit and conspicuous ability. Industry and professional bodies, particularly those concerned with science and technology, have their own part to play, both in securing greater prestige for the teacher and in making the schools and colleges more deeply representative of, and more closely in touch with, the nation. The universities in particular have a very significant part to play, both in turning the thoughts of undergraduates towards science-teaching as a career, and by a carefully thought-out series of measures as already indicated. Such measures should check the weaknesses of over-specialization, facilitate transfer between one faculty and another, and encourage communication between one discipline and another and that wide outlook and human understanding which are so essential in the man of affairs and which are the monopoly of no one faculty.

This is asking a great deal of the universities. It means abandoning some old ideas and practices and accepting some new responsibilities, certainly for closer co-operation with the schools, possibly also in adult education, to foster a deeper public understanding of the whole system of education and what it is attempting to do. It means looking at university policy not alone, but as part of the educational policy of Britain as a whole and putting fundamentals first and not departmental interest or administrative convenience. It means, as part of that whole policy, a clear understanding of the purpose and function of the university itself, not in isolation but in relation to what the colleges of technology, the technical colleges, the technical schools and the grammar schools themselves are doing to provide the nation with the trained man-power it needs. It may well be that the growing dependence of the universities upon public support will enforce on them, as Dr. Eric Ashby pointed out in his recent broadcast talks on the British universities, much closer attention to the interpretation of their work to the public. Prof. Niblett's book fully endorses Dr. Ashby's argument that, while to foster such a public understanding may be a condition of preserving academic autonomy, universities must also to some extent be in opposition to the superficial currents of society, as well as responsible to its deeper needs. The most important consequence, however, of attempts to re-think the functions of the university in relation to national needs and to re-shape policy in terms of educational policy as a whole could well be to stimulate communication between the specialists; as Dr. Ashby suggested, it might encourage the faculties of medicine, of science and of technology to adopt the long-established tradition of the teaching of arts subjects, and bring their own students face to face with genius, in the presence of which most educational problems evaporate.

ROMAN ROADS IN SOUTHERN ENGLAND

Roman Roads in Britain

By Ivan D. Margary. Vol. 1: South of the Foss Way—Bristol Channel. Pp. 255+17 plates and 11 maps. (London: Phoenix House, Ltd., 1955.) 42*s*. net.

THE excellent map at the end of Mr. I. D. Margary's book is its full justification, were justification needed. It is, in effect, the road-map of modern England. Even the industrial Midlands melt into it without major distortion. It is the sort of map from which the schoolroom study of the Roman Empire should properly begin, intelligent and purposeful with scarcely anything fortuitous about it. It might be described as the skeletal analysis of our countryside. The more is the wonder that more than half a century has elapsed since any survey was made of it on a commensurate scale. In 1924 the Ordnance Survey produced an up-to-date chart without commentary, and its successor, now in active preparation, will shortly present a revised version on a grander scale which must owe much to Mr. Margary himself. During recent years much has altered, roads have been lost and found, and methods of research have been improved, above all by the arrival of air-photography. Only in one respect are the aeroplane and the car inferior to the transport available to Thomas Codrington in 1903 or William Stukeley in 1776: the back of a horse offered the right sort of mobility and the perfect viewpoint for the actual fieldwork involved. Indeed, the author finds it necessary in his preface to warn motorists of the special dangers inherent in the point-to-point pursuit of Roman roads along the modern highway.

The book is a plain topographical description of the roads as they presented themselves to the explorer in 1954. Controversial points are dealt with conservatively, with no hint of the extravagancies which are prone to cloud this study. Here and there the identifications of place-names might have been argued a little more fully, and the impositions of Bertram of Copenhagen, which are not even yet as completely forgotten as they should be, more specifically countered. But these are

incidental matters, not for emphasis. Old problems of interest and some new ones arise at many points. The elaborate road-system in the environs of London is not yet entirely solved; for example, it is of more than pedantic concern to know whether the Watling Street from Kent by-passed the site of the city by way of the old Horseferry at Westminster and Hyde Park to the Edgware Road. It is worth recording that nearly half a century ago the late Sir Alfred Clapham, with this point in mind, secured permission to cut a trench in Hyde Park on the line which such a road should have followed, with entirely negative result. Again, how literally, if at all, does the Foss Way represent an early Roman frontier-line? The author's reading of the evidence at Cirencester is against a primary date for that mysterious Way, and his diagnosis is supported by that of Dr. Kathleen Kenyon at Leicester, where also the Foss appears to be secondary to the lay-out of the Roman town. Yet another complex of outstanding interest occurs at the famous site of the town and potteries at Castor in Northamptonshire. In matters such as these, the new survey will, it is to be hoped, serve as a stimulus to fresh investigation with the spade.

The air-photographs, mostly taken by Dr. J. K. S. St. Joseph for the University of Cambridge, are of superb and even dramatic quality. Less can be said of the ground-photographs, some of which seem to be out of focus. But the book is one which should be on the shelves not merely of the specialist but also of all who have an interest in the shaping of England, and an urge to refresh their history with the open air.

R. E. Mortimer Wheeler

PETROLOGY IN PERSPECTIVE

A Historical Survey of Petrology

By Prof. F. Y. Loewinson-Lessing. (Translated from the Russian by Dr. S. I. Tomkeieff.) Pp. x+112. (Edinburgh and London: Oliver and Boyd, Ltd., 1954.) 12*s*. 6*d*. net.

"ROCKS, like everything else, are subject to change and so also are our views on them." This sentence, from the preface, sets the key-note of this admirable and stimulating book by Prof. F. Y. Loewinson-Lessing, who was one of the "grand old men" of petrology referred to by Dr. S. I. Tomkeieff in a graceful tribute to his former professor. Concise in style and richly packed with material that should send many a student back to the original sources, the book traces the development of the subject from Zirkel's application of Sorby's techniques and pioneer microscopic studies of rocks to the conclusions reached by the author and his contemporaries in 1936, when the original Russian edition was published. The pre-microscopic age of petrology is only briefly discussed and is, perhaps, too rapidly dismissed.

The translation was completed in 1939, in time for Loewinson-Lessing to give it his blessing shortly before his death. Although Dr. Tomkeieff has wisely resisted the temptation to bring the book up to date, he has helped his readers by adding some fifty references to the more important books and papers that have since appeared. As it stands the book is a unity; to have extended it would have involved the introduction of new methods and techniques unknown to the author, such as those of isotope geology.

The subject is not primarily discussed in chronological order, but rather under the five main approaches to petrology: geological (modes of occurrence of rocks, petrographical provinces, etc.); petrographical (description and classification); chemical (culminating in geochemistry); experimental (crystallization of melts and mechanics of intrusion); and synthetic (problems of petrogenesis). The various problems, which to-day are being attacked with renewed energy by intensive observation in the field and by isotopic studies in the laboratory, are here seen in their historical perspective, but they remain the same problems, and the young petrologist could have no more inspiring introduction to the development of his subject. It is, indeed, a book that should be read by all geologists. Dr. Tomkeieff and the publishers have done their work well and deserve our thanks; not least, perhaps, for the very moderate price.

Arthur Holmes

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By A. R. Prest, assisted by A. A. Adams. (Studies in the National Income and Expenditure of the United Kingdom—3.) Pp. xiii+196. 42*s*. net.

A series published under the joint auspices of the National Institute of Economic and Social Research, London, and Department of Applied Economics, University of Cambridge. (Cambridge: At the University Press, 1954.)

THESE two books form part of a series of studies of the national income and expenditure of Great Britain, conceived and carried out under the general direction of Mr. Richard Stone by the National Institute of Economic and Social Research, London, and the Department of Applied Economics of the University of Cambridge. Work on the project was started in 1941 with the main object of "bringing together quantitative information relating to various aspects of the economic development of the United Kingdom, especially between the wars of 1914–18 and 1939–45". In the end it is hoped that all the estimates may be put together in the form of social accounts.

The task of collecting and bringing together the data in these two volumes must have been immense. An enormous variety of primary and secondary sources was consulted, adjustments had to be made to allow for changes in definition over time, and the reliability of the original figures had to be assessed. The sources that are used are everywhere described in detail, as are the methods of estimation employed. As an end result, Mr. Stone is able to present price and quantity series showing the demand for a large number of different foodstuffs, tobacco, rent, rates and water charges, and fuel and light. In the second book, dealing with the period 1900–19, Mr. A. R. Prest must necessarily use less reliable data, but his field of coverage is wider than Mr. Stone's; he deals

with expenditure on clothes, travel, books, amusements, life insurance and funerals, and domestic expenditure other than food, in addition to the topics covered by Mr. Stone. The expenditure on those items for 1920–38 will presumably be dealt with in Mr. Stone's forthcoming second volume.

By bringing this information together and arranging for comparability and continuity, the authors have provided an invaluable service, and their final results will be of value to a much wider circle than economists as a starting-point for further investigations. Mr. Stone's book, however, is not a mere storehouse of information. He attempts an analysis of market demand by combining the time-series that he has constructed with the results of investigations of family budgets and proceeds to calculate elasticities of demand for the commodities he deals with. There is a lengthy preface which deals with the aims and methods of econometrics, and the second part of the book contains an exposition of the theory of market demand and of the statistical procedures used in its analysis. This section contains a systematic account of multivariate analysis, based on methods of matrix algebra, which have been increasingly used in recent years.

A word of praise is due to the printers for a very fine job in producing the mass of material with such clarity.

SOLAR PHYSICS

The Sun

Edited by Prof. Gerard P. Kuiper. (The Solar System—Vol. 1.) Pp. xix+745. (Chicago: University of Chicago Press; London: Cambridge University Press, 1953.) 94*s*. net.

NOTHING comparable with this work has appeared since the publication of Vol. 4 of the "Handbuch der Astrophysik" in 1929. A comparison of the two volumes demonstrates impressively the strides solar physics has made in a quarter of a century. The identification of 'coronium', the recognition of H^- absorption, postulation of the carbon–nitrogen cycle, invention of the coronagraph (and more recently the interference filter), development of the rocket spectrograph and the magnetograph, the discovery of chromospheric flares and their terrestrial effects and of solar radio noise—all these advances, though solving some problems, have raised many others. It is small wonder, then, that adequate cover of a subject dealt with in 1929 by three authors in three hundred and fifty pages now takes twenty-three authors nearly seven hundred and fifty pages.

The expressed design of the editor, Prof. G. P. Kuiper, has been to collect and systematize all significant information on the Sun into a volume that will be at once a reference handbook for the specialist and a survey intelligible to anyone versed in the physical sciences. It is a big task, but he may claim, and be accorded, a fair measure of success. If, as the preface seems to indicate, each author used his own judgment as to what material is of sufficient importance to be included, one must congratulate the editor at least on his choice of contributors. The general level of appeal is extraordinarily uniform in a work with such heterogeneous origins, and if in some chapters the hypothetical reader with no previous astrophysical leanings may be repelled by an austere approach, this will not deter the specialist from turning to the work as a handbook of research.

All men of science deplore a growing tendency towards a restrictive nationalism in scientific books. Astronomy traditionally transcends national boundaries, and it is a pleasure to record in this instance contributions from authors in six different countries, in which no such tendency can be detected. One is especially glad to welcome the dedication: at least one American book in the past has contrived to describe the coronagraph without so much as mentioning the name of Bernard Lyot. It is regrettable that the present volume includes no contribution from the U.S.S.R.; but the cause can doubtless not be laid entirely at the door of the editor, who is as well aware as anyone how much solar research carried out in Soviet territories remains a closed book to Western readers.

The book opens with an introduction which quotes fundamental data and, bringing the general reader to about 1930, directs him to the particular one of the following chapters which is appropriate to his interests. The solar interior, the photosphere, and the chromosphere and corona are each discussed with thoroughness in a chapter contributed by an acknowledged leader in the field. These chapters are primarily concerned with the quiet Sun, in which each of these rather arbitrarily defined regions is in equilibrium with its neighbours. In contrast, Chapter 6 deals with the observable transient disturbances in the solar atmosphere, and with their terrestrial effects. Fascinating though this subject is, one wonders whether its importance justifies making this the longest chapter in the book. The next chapter is devoted to an observational and theoretical discussion of solar radiation at radio wave-lengths. That this is perhaps the most controversial in the book, and the one of which the conclusions are least likely to survive unchanged, is no more than to be expected in a subject barely ten years old. Chapter 8 is entirely theoretical and comprises a critical review of recent work in solar hydromagnetics. This subject is entirely new and bristles with so many difficulties that Prof. T. G. Cowling's survey is most welcome at this stage. The last chapter in the book is a miscellany of short contributions held together by no more than the title: "Empirical Problems and Equipment". This is not to say that it does not contain some of the most interesting pages in the whole book; certainly the illustrations here are magnificent. The book is rounded off with two useful appendixes giving a wealth of data on established solar observatories (optical and radio), their instruments and the type of work they undertake.

The book is impeccably printed on the calendered paper made necessary by including half-tone plates on a lavish scale throughout. The table of contents is admirably full; the alphabetical index, however, less so. Cross-references, necessarily frequent in so heterogeneous a work, are made maddeningly difficult to trace by the omission of chapter and section numbers from the page headings.

This volume is the first of four to be devoted to the solar system. It will give the solar physicist all he can reasonably expect in the way of an advanced text for many years to come. If the standards of the present work can be maintained in the forthcoming volumes of the series, astronomers and geophysicists will be heavily in Prof. Kuiper's debt.

A. HUNTER

CHARACTERISTICS OF SOME ANIMAL CALLS

By Dr. P. MARLER

Jesus College, and Department of Zoology, Madingley Ornithological Field Station, University of Cambridge

Sounds facilitating Location

IT is well known that some animal vocal sounds enable individuals to establish contact. The songs of various male birds, Orthoptera and Heteroptera[1,2], assist nubile females to find mates. Species which form groups at some stage of their life-history often maintain contact by special calls (for example, the great-tit, *Parus major*[3]).

The accuracy of sound location depends on the capabilities of the auditory receptors of the hearer, the physical characteristics of the sound signal and the distinctiveness of the sound, including the effects of distance from the source and of contrast with environmental noise. The auditory receptors of insects do not respond to pressure changes, like those of mammals and birds, but to variations in displacement. Since this is a vector quantity, they can locate sound sources directly[4], without reference to time, phase or intensity differences, and thus independently of frequency within their audible range (400–28,000 cycles in *Thamnotrizon*[2]).

Mammals, of which man has been most studied[5,6], and birds[7,8], locate sounds by making binaural comparisons of differences in phase, intensity and time of arrival. In contrast with insects, the efficiency of location thus varies with the frequency of the signal. Phase difference is most useful at low frequencies, because the information it provides becomes ambiguous when the wave-length is more than twice the distance between the ears. Also the refractory period of the auditory nerve (about 1 m.sec.) probably limits the perception of phase differences to frequencies less than 1 kc./sec. (that is, one cycle per m.sec.). Intensity differences are most useful at high frequencies, since obstructions in the path of a sound, such as a head, only cast appreciable sound shadows when their dimensions are greater than the wave-length of the signal. Time-difference can be used throughout the auditory range. It is clear that the most readily located signals will be complex ones, which provide clues for all three methods.

The song of the male chaffinch, *Fringilla coelebs* (Fig. 1), is known from field observations and from experiments with recorded songs to attract unmated females to its point of origin, and to repel rival males[9]. It has a wide frequency spectrum, centred on 3 kc./sec., which is within the range of maximum sensitivity of the chaffinch ear[10]. It is rich in sudden changes of frequency, which provide points of reference for binaural time-comparisons. Experiment suggests that intensity differences are actually most significant in location by the chaffinch[11], no doubt because its ears are so close together that time- and phase-differences are difficult to perceive (though for larger birds they are probably important). Emphasis on the use of intensity-differences would tend to encourage high frequencies in song, which are most effectively blocked by the head.

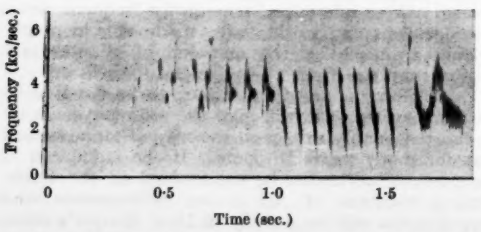

Fig. 1. A sound spectrogram of a song of a male chaffinch. Note the many sudden changes in pitch and the wide frequency range

But to serve its functions, song must be audible at a considerable distance; this sets an upper limit to frequency since, as it increases, the rate of attenuation with distance also rises rapidly. Furthermore, high-frequency sounds are easily reflected even by small objects such as tree branches, making their original source difficult to locate. Another aspect of the function of song is that it is directed to members of the species, and should therefore differ distinctively from the songs of other sympatric species. This is true of the chaffinch in Western Europe, and in the Azores[12]. It is clear from the use of song characteristics in distinguishing closely related species (for example, *Phylloscopus trochilus*, *P. collybita* and *P. sibilatrix*[13]) that this is usually the case. But when the number of co-habiting species is reduced, as on small islands, songs may become much more variable (for example, notes of the blue-tit, *Parus caeruleus*, on Teneriffe[14] and the goldcrest, *Regulus regulus*, in the Azores[12]).

Thus the physical characteristics of chaffinch song are closely adapted to the part it plays in life. The sound signals of the domestic fowl, *Gallus domesticus*, which attract small chicks[15], share the characteristics of segmentation or repetitiveness, brief duration of the component notes, and the presence of relatively low frequencies (less than 800 c./sec.). Much of the energy is concentrated at the start of the notes. Like chaffinch song, these characteristics can be related to the facilitation of sound location, the low frequencies to allow phase-difference to be used, the segmented 'click-like' properties for time-difference.

Sounds confusing Location

There is a conflict in many animals between the need to appear conspicuous to their own species and inconspicuous to predators or prey, which is manifest in their coloration[16] and also in their vocalizations. Small Passerines have two distinct responses to a hawk or owl[3,9,17]. If the bird of prey is perched, they make themselves conspicuous by 'mobbing' behaviour, which attracts other birds' attention to the predator; if it is in flight, they dash for cover, and hide. Chaffinches use quite different calls in each case. In the first they give a 'chink' note (Fig. 2), which provides abundant location clues; in the second, males give a high, thin 'seeet' note. The former is easily located by man, the latter only with difficulty, and the same is probably true for predators.

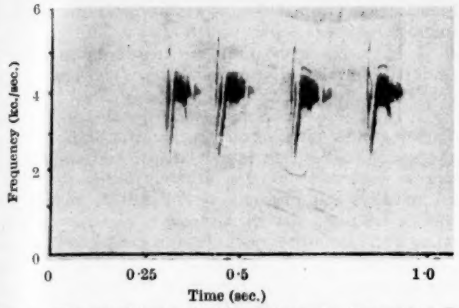

Fig. 2. Four 'chink' calls of a female chaffinch. This call shares with song the characteristics of discontinuity and wide frequency-range

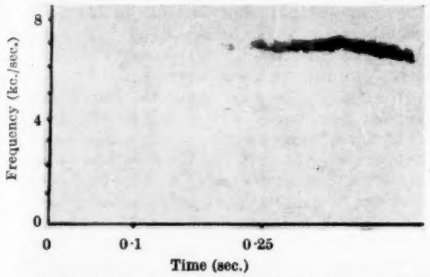

Fig. 3. A 'seeet' call of a male chaffinch, evoked by a sparrow hawk. Note the constant pitch and the absence of any sharp discontinuities

Pure tones in the region of 2–5 kc./sec. are difficult for man to locate because they are too high for binaural comparisons of phase-difference, and too low for there to be appreciable intensity differences, so that only time-differences can be used[6]. In birds of prey such as owls and hawks, the lower limit of this range of frequencies, which are difficult to locate, is probably similar to that of man (perhaps set by the refractory period of the auditory nerve around 1 kc./sec.). The upper limit must be considerably higher, since sound shadows only become appreciable when the wave-length approximates to the diameter of the obstruction. Thus the 'seeet' call of the male chaffinch probably gives no clues to its location by phase- or intensity-difference. It also begins and ends imperceptibly (Fig. 3), and thus gives no clues for comparison of binaural time-differences. Finally, its wave-length (about 5 cm.) is small enough to result in free reflexion from the trunks of small trees. Thus the 'seeet' call seems to be adjusted to avoid giving location clues of any kind to predators. Yet it serves to communicate the presence of danger to other chaffinches, which fly to the nearest cover irrespective of the location of the calling bird. Imitations which have similar characteristics evoke an identical response[9].

It is interesting to find that other unrelated Passerines such as the blackbird, *Turdus merula*, missel thrush, *T. viscivorus*, and various titmice[3] and buntings (Andrew, unpublished work) have 'hawk' calls with similar characteristics (see Fig. 4), no doubt for the same reasons. Many juvenile Passerines, which are very susceptible to predation, have calls which are difficult for man to locate (for example, the wren, *Troglodytes troglodytes*[18]) and which resemble the 'hawk' calls in structure and frequency (Fig. 5). It is possible that certain species such as the hawfinch, *Coccothraustes coccothraustes* (Fig. 6), have even adapted their contact calls to give few location clues to predators, as may be true of some small rodents and insectivores. The song of the grasshopper warbler, *Locustella naevia*, is perhaps ventriloquial for the same reason.

The warning signals of the domestic fowl differ as a group from those which attract chicks, and are in many ways their opposites[15]. They are of relatively long duration, show little segmentation or repetitiveness, and lack very low frequencies. Although never as high-pitched as the 'hawk' calls of small Passerines (400–2,700 c./sec.), they appear otherwise to be very similar, in the absence of clues by which predators might locate their source by time-difference, perhaps by phase- and intensity-differences as well.

Vertebrate predation must be an equal problem for insects which communicate by sounds. Analysis reveals that most Orthopteran songs have their main

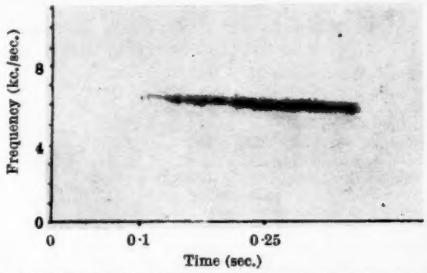

Fig. 4. A 'hawk' call of a male blackbird, scarcely distinguishable from that of a chaffinch

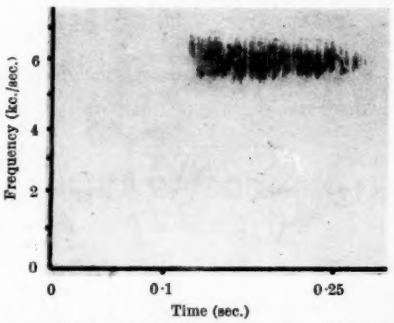

Fig. 5. The 'food-begging' call of a young wren. This shows many of the characteristics of the 'hawk' calls

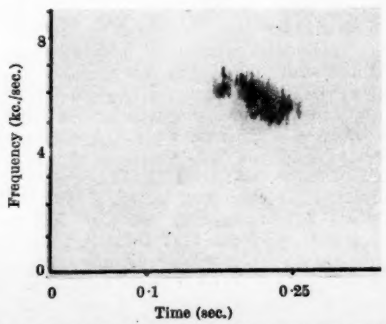

Fig. 6. A 'seep' call of a female hawfinch, used for maintaining social contact in winter

energy in the region of 6–14 kc./sec.[19]. Signals of this frequency may well be as difficult for their bird predators (Laniidae, Tetraonidae, etc.[20]) to locate as for man. Also they are well above the range of maximum sensitivity of most birds, as so far investigated[21], and will be freely reflected by even small obstructions. Exceptions are the songs of various Grylloidae (2–4 kc./sec.)[19,22], which, in contrast with other Orthoptera, are largely crepuscular or nocturnal and, with their cryptic and often subterranean habits, may be less exposed to predation.

Another method of confusing predators may be to sing in communal groups, thus making it difficult for any one individual to be located. Pringle (unpublished work) has suggested this explanation for the habit among Cicadas (Heteroptera), and it might also be applied to the communal singing of frogs.

Thus it appears that many of the sounds used in bird and insect 'language' have not been chosen arbitrarily, but are directly adapted in structure to the function they have to perform.

I am indebted to Prof. J. B. S. Haldane and Dr. W. H. Thorpe for criticism of this article.

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WILLIAM HIGGINS, CHEMIST (1763–1825)

By Prof. J. R. PARTINGTON, M.B.E.

ALTHOUGH William Higgins was, in his time, one of the distinguished group of Irish chemists which included Kirwan, singularly little is known of many aspects of his life, and some inaccurate statements about him and his work have been repeated by the few who have written about him. Prof. T. S. Wheeler, of Dublin, who has for some years been engaged in a study of Higgins, has recently published two articles[1] based on primary sources, including some which were unknown to previous writers, and these articles throw new light on several aspects of the life and work of Higgins.

William Higgins was born at Collooney, Co. Sligo, probably in 1763, and died in June 1825. He was the nephew of Bryan Higgins, also known as a chemist. He was from 1787 until August 1788 at Pembroke College, Oxford, previously matriculating at Magdalen Hall in 1786. He is said to have been "operator" (lecture assistant) to Beddoes, the reader, who succeeded Austin, the professor of chemistry, early in 1788. On leaving Oxford he went to London. Since he says himself that he assisted his uncle in numerous experiments which Bryan Higgins published in a book in 1786, he must have been in London before he went to Oxford. The reason why he left Oxford after so short a stay and without a degree is not clear; but since he published his book criticizing the phlogiston theory in 1789 he must have been working on it in Oxford, and since Bryan Higgins was a supporter of the phlogiston theory and made some original contributions to its later aspects, he may have withdrawn his support of his nephew. This, however, is only a conjecture.

In January 1792 Higgins was appointed chemist at Apothecary's Hall, Dublin. Hitherto, little has been known of this period of Higgins's career, and Prof. Wheeler is the first to have had access to the relevant minute books. Higgins received a salary of £200 a year, with apartments, coals and candles, taking over a "small back room" in May. He fitted out a laboratory. His salary came into arrears, and in 1795 Higgins asked for payment in such terms that his employment was terminated, the governors borrowing £200 to pay him off. In 1795 he was appointed part-time "Chymist" to the Irish Linen Board, at a salary of £100 a year, which appointment he held until 1822. He did a considerable amount of good work for the Board, publishing in 1799 an "Essay on Bleaching". His merits were appreciated by Kirwan, a phlogistonist whose theories Higgins had attacked in his book, and it was on Kirwan's recommendation that Higgins was appointed in 1795 to supervise the Leskean Collection of minerals of the Royal Dublin Society, becoming professor of chemistry and mineralogy by an Act of the Irish Parliament passed in 1796. He began to lecture in 1797. He had been elected to the Royal Irish Academy in 1794 and was elected F.R.S. in 1806 (his nomination certificate being signed by Davy), but first signed the charter book and obtained admittance in May 1817.

Although he lived in rooms in Dublin, Higgins left a considerable amount of property on his death, having purchased lands for £2,000 and £6,800 during 1818–23. He had a reputation for eccentricity, and many anecdotes of him were current. Davy, in his obituary notice, complained that Higgins did little in the later years of his life, but he seems to have been kept busy in his various appointments.

Higgins is best known for his book, "A Comparative View of the Phlogistic and Antiphlogistic Theories", published in 1789 and again in 1791. In this he argues against the phlogiston theory, which Kirwan had supported in an "Essay on Phlogiston" in 1787. An example of his style is provided by the following extract from the "Comparative View": "Although I do not think sulphur contains phlogiston, or the solid matter of light inflammable air, I by no means suppose it to be a simple body, but to be relatively to our knowledge of chemistry, as simple as the earths or the two fixed alkalies, all of which I make no doubt will be analysed at some future period, when the science of chemistry will be more cultivated than at present, by men of genius, fortune, and leisure" (p. 120). The book contains some new discoveries, such as the solution of iron in sulphurous acid without the evolution of hydrogen, and an appendix on an analysis of a human calculus which was presented to the Royal Society but was not printed. It also describes some ingenious quantitative experiments, for example, on the composition of

nitric acid and of hydrogen sulphide (which, however, he regarded as a mere solution of sulphur in hydrogen, not a compound). These experiments were made in Oxford and possibly in his uncle's well-known laboratory in Greek Street, Soho, in London.

Higgins deals with chemical combination on the basis of the union of 'ultimate particles' of elements, and he clearly recognized, probably for the first time, that a particle of one element may unite with more than one particle of another, in the oxides of nitrogen up to five particles of oxygen combining with one of nitrogen. In this the law of multiple proportions is implicit. Applications of the atomic theory to chemistry had been made before, notably by Bryan Higgins, who explained the union of one particle of each of two elements to form a molecule (a name used by him) of a compound, calling the process 'saturation', a name also used by William Higgins. Bryan Higgins used the idea of central forces, while William used a different idea, more akin to modern views on valency. Bryan Higgins hints only obscurely that perhaps two particles of an element may saturate one of another.

In his "Comparative View", William Higgins paid little attention to the weights of the particles, and only once in the book does he hint that they may have different weights, without attempting to determine them. He does not seem to have realized the novelty of his conceptions.

Some have said that Higgins thought that the particles of different elements were equal in weight, but Prof. Wheeler concludes that this is unlikely. It is more probable that he assumed nitrogen, oxygen and sulphur equal (14, 16, 32/2) and that he knew that the particle of hydrogen was much lighter. He seems to have thought that the matter of all particles has the same density, and that the weights of the particles are proportional to the sizes of the hard nuclei, apart from the atmospheres of fire (caloric). He thus supposed that the particles in different gases are at different distances from one another, so that he could not draw conclusions from the densities, as Avogadro afterwards did. He did, however, consider that the numbers of particles in equal volumes of gases under the same conditions of temperature and pressures were in simple numerical ratios. He arrived at reasonable views on the composition of several molecules, such as that of water (HO) and the oxides of sulphur (SO and SO_2) and nitrogen (NO, NO_2, NO_3, NO_4 and NO_5). He used symbols for the particles of different elements—nitrogen P, sulphur S, oxygen D or *d*, hydrogen I, etc.—and he also made an approach to the idea of valency bonds, drawing lines between the symbols of the elements and assigning arbitrary numbers to the forces between the particles. He supposed that the force of a central particle was progressively weakened as more and more particles of another element were attached to it, the bond strength being the sum of the force of an attached atom and the force of the central particle divided by the number of particles attached to it. This idea enabled him to discuss in a very ingenious way what would now be called transition complexes. In these associations of particles, the forces are weakened when another body is brought up, and the effect of this is transmitted through the complex, leading to rearrangement and reaction. In such cases he used the idea of a preliminary orientation of particles, which had also been used by Bryan Higgins. These views are more ingenious than those of Dalton, who followed Newton in using central forces, which enabled him to explain the properties of mixed gases, a problem not considered by Higgins.

Some years after Dalton published his atomic theory, Higgins in 1814 wrote "Experiments and Observations on the Atomic Theory", in which he reproduced parts of the "Comparative View" with the intention of showing that he had anticipated Dalton. In many cases, however, he reads into these more than he said in 1789 and alters some of his conclusions. He suggests that Dalton had known of, and used, his earlier book in formulating his theory; but no evidence of this has ever been produced[2]. Prof. Wheeler believes that Dalton was unaware of the work of Higgins. Higgins and Dalton both used atomic theories in explaining chemical changes. Higgins was the first to point out clearly the combination of atoms in multiple proportions, and he used the idea of forces linking atoms in explaining reactions, adumbrating the idea of a transition state, but he paid little or no attention to the weights of atoms. Dalton's contribution was the idea of finding the relative weights of atoms and so explaining the quantitative laws of chemical combination, but he paid little attention to attractive forces exerted between the atoms. Dalton's theory includes the law of multiple proportions and, what is important, the law of reciprocal proportions, which Higgins, with his neglect of atomic weight, did not see was a consequence of the atomic theory. The atomic theories of Higgins and Dalton differ in important respects, and it is pointless and probably incorrect to say that Higgins anticipated Dalton. It was Dalton's theory which was developed in the nineteenth century, and many of his ideas appear in the modern atomic theory. Higgins was mainly concerned in refuting the phlogiston theory, and since this was no longer of interest to later chemists his atomic theory, which formed part of his argument, was not properly appreciated. He did not develop it himself and seems to have realized that he could have done so only after Dalton's theory was published.

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SEMICONDUCTORS AND TRANSISTORS: SOME CURRENT PROBLEMS

By Dr. J. R. TILLMAN

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WHEN Bardeen and Brattain announced their discovery of transistor action in 1948, it was foreseen that much research and development would be needed before widespread applications became possible. What has followed, however, has been on a scale many times greater than generally expected. The more fundamental research has been fruitful, as witness the reports of the international conferences on semiconductors held at Reading (1950) and Amsterdam (1954). It has predicted new effects and new applications and has led to new designs of transistor. Advances in technology have also been striking, though some secondary effects, not yet well understood, introduce unwanted features in transistors.

Transistor Materials

Germanium and silicon remain the only important transistor materials. Most of their properties as semiconductors—for example, the dependence of resistivity and Hall coefficient on impurity content (usually of a trivalent or pentavalent element) and on temperature, and the wave-length limit of the optical absorption (and the related energy gap)—have been investigated in detail. Interpretations of some of the electrical properties in terms of fundamental quantities demand that the effective mass, m^*, of the charge carriers be dependent on the direction of motion relative to the crystal lattice, and differ, sometimes by a factor of more than ten, from the rest mass, m_0, of a free electron. Attempts have recently been made to measure m^* by a more direct method; the angular frequency, ω, of an electric field E at which a specimen of a semiconductor exhibits a cyclotron resonance (a peak in its absorption spectrum), when a steady magnetic field H is applied at right angles to E, is simply qH/m^*c. The conditions necessary to achieve unambiguous answers from the cyclotron resonance measurements are stringent, requiring that the carriers have a mean free time of at least a few cycles of the alternating electric field—a condition met only by the combination of low temperature (for example, 4° K.), at which collisions with phonons are greatly reduced, and high values of $\omega/2\pi$ (for example, 10^{10}–10^{11} c./s.). The much reduced thermal ionization of the impurity centres at the low temperature provides too low a density of charge carriers, which must be supplemented by, for example, photo-injection. The values of m^*/m_0 obtained confirm a dependence on the orientation of the crystal under test with respect to the direction of H and differ for holes and electrons. Theoretical computations of the energy band structure for germanium and silicon have been extended to sufficient points in momentum space to account, at least qualitatively, for the cyclotron resonance results.

The effects which limit the life-times of minority carriers (such as those injected by the emitter of a transistor into the base region or produced by photons of sufficient energy) are only partially understood and not well controlled. Thus nickel and copper present large cross-sections for the capture and recombination of holes in n-type germanium; parts in 10^{11} of nickel (parts in 10^{10} of copper) could account for most of the recombination occurring in much of the n-type monocrystalline germanium prepared to-day. The same two elements also have large capture cross-sections in p-type germanium where they act as recombination centres for electrons. The segregation constants of both elements, in germanium, are very small, making zone-refining apparently efficient, but they are not accurately known, partly because both elements diffuse comparatively rapidly into solid germanium at elevated temperatures; both exhibit retrograde solid solubility in germanium. Control of life-time by the addition of either element to molten germanium from which single crystals are afterwards drawn is therefore difficult. There are, however, applications which call only for a minimum value of life-time, involving no addition of a material of high recombination cross-section. Physical imperfections, particularly the dangling bond associated with the edge component of dislocation lines in the otherwise near-perfect germanium, can also act as recombination centres; their numbers must be controlled, both for this and other reasons.

Transistor Technology and Physics

The properties of the surfaces of semiconductors are insufficiently understood. No simple complete model exists for the rectifier formed at the contact between a sharp metal point and a piece of germanium or silicon—and in general none for a formed point contact, that is, one at which sufficient electrical energy has been rapidly dissipated to produce local melting, followed by rapid cooling. Experimental studies have been made; but the interpretation of some depends on details not well under control—for example, the structure and composition of surface layers.

Changes in the contact potential of a surface when exposed to a sequence of atmospheres have been studied. Layers of p-type conductivity form on n-type material exposed to an oxidizing atmosphere and of n-type conductivity on p-type germanium exposed to water vapour; water vapour may, however, counteract the short-term effect of an oxidizing atmosphere on the growth of layers. The effective area of the layer (more usually called a channel) adjacent to a p–n junction increases with reverse bias across the junction, but the breakdown voltage of the junction between the channel and the underlying material may be much less than that of the main junction.

The rate of recombination of minority carriers can be very high at surfaces, and, in a transistor formed by alloying two small pellets of indium opposite one another on a thin wafer of germanium, can predominate over that in the bulk material, unless the surface material damaged in preparing the wafer is completely removed before alloying, and the final etching, washing and drying carefully attended to. At the moment, surface effects may be the most important of those responsible for the failure of some transistors to have, and retain, the properties predicted.

The alloying process, though widely used, has uncertainties. The indium melts and dissolves germanium until the solution is saturated. The first part to solidify on cooling takes the structure of the underlying undisturbed germanium and may be strongly p-type (because indium is trivalent) if the alloying temperature is high enough. The continuity of the germanium across the p–n junction may have regions of imperfection, however. None the less, alloy diodes, carefully processed and sealed in a dry inert gas, can have voltage/current relationships little different from those calculated, indicating that any imperfections can be apparently unimportant initially; they may still play some subsequent part in changes of performance, however.

The reliability of transistors will probably ultimately reside in the vital regions of the surface and bulk near the junctions or contacts. High electric fields (for example, 3×10^4 V./cm.) exist at the collector junction or contact, where the working temperature may, due to the power dissipation, be 70° C. or more in germanium and 150° C. in silicon units. The drift of metal ions and the diffusion of atoms across the boundary, into the base region, particularly in regions of local imperfection, may well set one limit to the life of units. The high field extends to the periphery where it may cause dielectric breakdown in any protective film, and may lead to

shunting of the junction by ionic conduction and to erosion of the germanium at the edges of the junction.

A wide variety of changes of performance can be noted when units are exposed to wet and dry atmospheres, ozone, halides and the vapours of some organic liquids; the effects of high humidity are particularly detrimental when small quantities (for example, $1/10^6$) of salts of nickel or copper are present in the final washing water. Because these metals are often used as connecting stubs or leads, great care needs to be taken in manufacture to prevent their transfer to unwanted places.

Some new designs of transistor have involved new techniques and therefore require new studies of basic phenomena. The surface barrier transistor, made by electrolytically etching two wells opposite one another in a wafer and afterwards electrolytically depositing or evaporating emitter and collector electrodes in the wells, depends for its action on the contact between the metal coating and the semiconductor as left by the electrolytic etch. Platinum, indium, copper, lead and antimony are among the metals used. As with point-contact rectifiers, the work function of the metal seems to have little influence on the overall performance. No satisfactory theory has yet been given to account for the high hole content of the current flow across such metal–semiconductor contacts.

The solar and atomic batteries are recent additions to the possible uses of silicon p–n junctions; each converts some of the energy of a radiation, solar or β, respectively, via the production of hole-electron pairs in the vicinity of the junction, into electrical power. Problems of damage to the lattice, with degradation of performance of the battery, may be severe in the atomic unit.

New Semiconductors

Germanium and silicon are not ideal materials for crystal valves for several reasons. Germanium is a comparatively rare element; valves made from it lose much of their performance when operated at ambient temperatures above about 70° C. Silicon presents difficulties of purification; its technology involves accurate control of temperatures around 1,420° C. The mobilities (μ) of carriers in germanium and silicon ($\sim$ 400–4,000 cm.²/sec. V.) limit the speed of response of transistors. Searches continue to be made for other transistor materials less severely limited in the above ways. The compounds of elements of Group III with elements of Group V, for example, indium antimonide and gallium arsenide, were among the first to receive attention. The properties of the constituent elements disappear in the compounds, which have a diamond-like structure and the electrical properties of semiconductors. Values of μ as high as 75,000 cm.²/sec. V. have been reported for electrons in indium antimonide, but the accompanying energy gap is less than 0·3 eV., and the life-time, τ, of minority carriers may be severely limited (perhaps to < 1 μsec.). The small energy gap prohibits useful transistor action at room temperature; for a base region of indium antimonide to be extrinsic it must contain about 10^{17} impurity atoms per cm.³ and may be nearly degenerate. Collector barriers would be very thin and unable to withstand any usable reverse voltage. Reverse currents at pn junctions will be large because of the small gap, large μ and small τ. Some other compounds have more appropriate values of energy gap, but only moderate values of μ. The search has extended to other binary compounds (elements in Groups IV and VI and also V and VI) and to ternary compounds—for example, $CuInSe_2$—the structure of which also resembles that of diamond. Some, though not suitable for transistors, have extended the range of other electrical properties. Thus the Peltier effect at the junction between bismuth and bismuth telluride has been made to produce a temperature difference of 26° C., and that between n- and p-type bismuth telluride a difference of $\sim$ 40° C. Some attention has been paid recently to quaternary compounds having the stannite structure, also akin to diamond.

Problems in applying Crystal Valves

It is now possible to assess more adequately the likely uses of crystal valves. Diodes offer advantages of size, lack of a heater, small capacitance and, sometimes, rapid response. Triodes offer advantages of size, lack of a heater and some additional facilities compared with thermionic valves. The diodes bring few new problems; their noise factors are not well understood, but at radio frequencies are usually tolerable. Minority-carrier storage can set a limit to their speed of operation as switches, for example, in computer circuits; forward current results in an excess of minority carriers near the junction or contact, which prevents the diodes instantaneously becoming of high impedance when a reverse voltage is applied. Recovery times can vary from about 0·01 μsec. to 10 μsec. Triodes set many more, and sometimes severe, problems. The noise factor can be intolerable at audio-frequencies for some uses; here the dominating component at a frequency f is often proportional to f^{-n}, where n is about 0·9–1·2. The equivalent circuits are more involved than those of thermionic valves, and it is not always easy to relate the components of the equivalent circuit which suits the engineer to those preferred by the device designer. Methods of circuit analysis and design both for large-signal and small-signal applications are being evolved, but the limitations of upper working temperature (less stringent for silicon units), of power handling capacity and of frequency response continue to restrict the field of applications.

OBITUARIES

Prof. Albert Michel-Lévy

Albert Michel-Lévy was born at Autun on July 3, 1877. His father, Auguste (1844–1911), was a very distinguished geologist and mineralogist, best known for his fundamental work on the relationship of chemical composition to optical properties in the feldspar group, which is still used as the basis for the identification of members of this most important group of rock-forming minerals. Albert at first studied agriculture and forestry at Nancy; but he soon found an opportunity to turn to geology, and in 1901 he entered the Collège de France as a student of Ferdinand Fouqué's. His early work was on the rocks of the central massif of France in Morvan and Le Loire, and his thesis for his doctorate embodied the results of many years work in that region. In 1913 he succeeded to Louis Gentil as a lecturer in petrography at the Sorbonne. Here he carried out many investigations of volcanic rocks and of mylonites, illustrating his papers on these rocks by photomicrographs of remarkable excellence. He was ever ready

to lend his special skill with the polarizing microscope to workers in fields other than petrography, and this led, happily, to some work on the birefringence of nitrated cellulose and in turn to work on other explosives. Together with Henri Muraour he studied, and photographed under the microscope, the behaviour of single crystals of explosive substances, observing the products of the explosion, the light flash, and the shock waves. Later they extended their observations to the modifications in the shock waves when explosion took place in one of the heavier gases like argon, comparing these with the effects seen in atmospheres of lighter gases.

This work on explosives suggested to Michel-Lévy a way of synthesizing rock-forming minerals under pressure and in presence of water vapour. The materials for the synthesis were enclosed in a 'bomb' cleverly designed to accommodate also a small explosive charge. The 'bomb' could be heated in an electric furnace at first to a temperature of 200°, at which the explosive detonated, producing the high pressures required in the closed 'bomb'. This was then heated to higher temperatures and could be kept there for days or weeks as desired. The identification of the minerals synthesized in these experiments was made by means of X-rays by Jean Wyart, and in later experiments they had the collaboration of one of Michel-Lévy's daughters, now Mme. Mireille Christophe-Michel-Lévy, by whom the work is still being carried on.

Twice Michel-Lévy's scientific work was interrupted by wars. He came of a family devoted to the service of France. His grandfather had served in the Crimea as a surgeon and became a very distinguished officer in the French Army medical service. In the First World War Albert Michel-Lévy, *Capitaine de chasseurs à pied* and later *Chef de Bataillon*, was twice grievously wounded, and he ended the war as an officer on the General Staff. He was made a chevalier of the Légion d'Honneur, of which he became an officer in 1920, and commander in 1946. In the Second World War, after the fall of France, he was removed from his post at the Sorbonne because of his Jewish ancestry. Protests at his removal were eventually successful in having the interdiction withdrawn in January 1942, and he was able to resume his work, though not in his own laboratory. However, worse was in store. His only son, Roger, fighting in the resistance, was taken prisoner and shot in February 1944. The loss was irreparable. Michel-Lévy's health was never again very good and he retired from his professorship in 1946, though he continued work with Jean Wyart and his daughter until 1948. He died in Paris on May 2, 1955. He was made a professor of the Sorbonne in 1936, and was elected a member of the Academy of France on January 22, 1945.

W. Campbell Smith

Prof. Madison Bentley

Prof. Madison Bentley died in California, U.S.A., on May 30. He was born at Clinton, Iowa, on June 18, 1870. His early training was at the University of Nebraska. He then went to Cornell University where, in 1898, he obtained the Ph.D. degree. At Cornell he remained, first as instructor and then as associate professor of psychology, until 1912. During 1912–28 he was professor of psychology and director of the Psychological Laboratory at the University of Illinois. In 1928 he succeeded Titchener at Cornell as Sage professor of psychology, and there he remained until his retirement from official life. He became president of the American Psychological Association in 1925, he was a Fellow of the American Association for the Advancement of Science, chairman of the Division of Anthropology and Psychology in the National Research Council; and he was editor of the *Psychological Index* (1915–24), of the *Journal of Experimental Psychology* (1926–30) and co-editor for many years of the *American Journal of Psychology*.

Madison Bentley achieved a position of great influence in the relatively early days of experimental psychology in America. He was of a modest and friendly disposition, a man of complete intellectual honesty, yet willing to try to see something good in all the many systematic, and often highly dogmatic, approaches to psychology which characterized the end of the nineteenth and the beginning of the twentieth centuries. This temper of mind made him an admirable editor, and his successful editorial work, as he himself recorded, broadened his knowledge and increased his tolerance. He wrote widely but mostly in journals, or in books of the familiar American 'portmanteau' kind. There were two volumes of his own: "The Field of Psychology", published in 1924, and "The New Field of Psychology", which appeared about ten years later. In the second, Bentley showed himself rather surprisingly sympathetic to practical and applied developments of experimental psychology.

When Prof. Carl Murchison got the excellent idea of producing a series of volumes to be called "History of Psychology in Autobiography", Madison Bentley was naturally one of the people approached for an early contribution. He wrote a beautifully unassuming account of his intellectual development (Vol. 3, p. 53; 1936). He acknowledges his debt to Titchener, and it is characteristic that he should select one item of this debt as most important. He had "submitted a cherished manuscript" for criticism and got it back with these remarks: "Here it is. I don't think that I have ever told you that I thoroughly disliked anything that you had written. I do this. It is decidedly bad. Cut out your figures and have done with your fine writing". This, says Bentley, "was a major operation without anæsthetic. Recovery was slow, but it left my organism saner".

Whether or no this was the reason, it was the sanity and dependability of his judgment, as well as the wide range of his knowledge, that won for Bentley the deep respect and admiration of psychologists everywhere.

F. C. Bartlett

Mr. G. W. Lines, C.B.E.

George William Lines, director of agriculture, Sierra Leone, will be well remembered in West Africa and especially in agricultural circles of Nigeria and Sierra Leone, where he had a long and distinguished career. He died at his headquarters at Njala on February 11 in his fifty-second year.

After graduating from St. Catherine's College, Cambridge, in 1924, he obtained a Cambridge diploma in agricultural science before he joined the Colonial Agricultural Service in 1925. He spent the earlier part of his service in Nigeria, where he was noted for the enthusiasm and energy he put into his work and for his genial personality. He was particularly successful in obtaining the co-operation and confidence of the native farmers to a degree seldom attained by other officers in the Service.

Lines took a leading part in establishing the co-operative preparation and marketing of cocoa in the Western Region, and later he initiated the planting of improved oil palms to replace the wild palms on which the farmers relied. In Nigeria perhaps he will be best remembered in the Bida area where, during the War, he established a thriving local fibre industry which proved of lasting benefit to the farmers and met an urgent demand for materials previously imported and then practically unobtainable.

On his transfer to Sierra Leone in 1944, he gave outstanding service in the organization of supplies and later assisted in the improvement of production and quality of piassava, a product for which Sierra Leone is famous. He was promoted to principal agricultural officer in 1945, deputy director of agriculture in 1949 and to director in 1951. It was in this latter post that he achieved his most outstanding success. Realizing the impossibility of increasing food production on the overworked and eroded uplands, he went boldly forward to apply mechanization to the cultivation of swamp rice on the vast areas of coastal and inland riverain swamps. The initial experiments met with immediate success, from which he evolved a policy which has led to the provision of a service with mechanized units over large areas of the country. In 1942 he was made an M.B.E. and advanced to C.B.E. in 1955.

By the death of G. W. Lines the Colonial Agricultural Service has lost an outstanding figure, and he leaves behind him many friends, Europeans and Africans alike. His enthusiasm was unbounding and infectious, his initiative exceptional and he gave unstinted encouragement to his staff from the most junior upwards. T. N. GREEVES

NEWS and VIEWS

Imperial College of Science and Technology, London

THREE new chairs have recently been created at the Imperial College of Science and Technology, London, and the appointments to them are as follows: aeronautical structures, Dr. J. H. Argyris; applied science in the Mechanical Engineering Department, Prof. D. G. Christopherson; and light electrical engineering, Prof. A. Porter.

Prof. J. H. Argyris

UNTIL the appointment of Dr. J. H. Argyris to the new chair of aeronautical structures at Imperial College, all professors of aeronautics in British universities were primarily associated with aerodynamics. This has inevitably biased students of aeronautics in favour of aerodynamics and has had the result that too few graduates with a primary interest in structures have entered the aeronautical engineering profession. The formation of the present chair will help to change this somewhat unsatisfactory state of affairs. Prof. Argyris studied at Munich and Zurich. He spent some years on the technical staff of the Royal Aeronautical Society, during which period he wrote papers on tapered tubes (representing aeroplane wings), diffusion of loads and panel instability, and wrote an important contribution to the "Handbook of Aeronautics". In 1949 he joined the staff of Imperial College, and in the following year was appointed reader in aeronautical structures by the University of London. Since then, an aircraft structures laboratory, including equipment for the study of fatigue, has been built up at the College. Prof. Argyris's work and published papers since 1949 have been on energy theorems, approximate stress analysis, matrix formulation of structural analysis, instability of panels, experiments on open tubes, and fatigue investigations on bonded light alloys. He is working at present on the statics and dynamics of complex aeronautical systems with particular reference to the use of digital computers.

Prof. D. G. Christopherson

PROF. D. G. CHRISTOPHERSON was educated at Sherborne School and at University College, Oxford, graduating in engineering science in 1937. After a year at Harvard University as a Henry Fellow, he became research assistant to Sir Richard Southwell and took his D.Phil. in 1940. During the Second World War he worked for the Research and Experiments Department of the Ministry of Home Security on the subject of airborne blast, underwater shock waves and other effects of explosions, and also on the design of structures to resist these effects. In the latter part of the War his work was not so much concerned with defence as with the selection of weapons for attack on specific objectives. After the War he became a lecturer in engineering in the University of Cambridge and a Fellow, later bursar, of Magdalene College. In 1949 he was appointed to the chair of mechanical engineering in the University of Leeds. Prof. Christopherson's research and publications have been mainly on three lines: lubrication, dynamic stress analysis and plasticity. The chair of applied science at Imperial College has been created as part of the expansion plans of the College. The new professor will be particularly concerned with the methods of teaching engineering students of all kinds during their first year at the College, as well as with his own research and postgraduate work.

Prof. A. Porter

PROF. ARTHUR PORTER is a graduate of the University of Manchester, where he became an assistant lecturer in physics. Before the Second World War he was a Commonwealth Fellow in physics and electrical engineering at the Massachusetts Institute of Technology, and during the War was engaged on special work for the Admiralty and Ministry of Supply. In 1946 he went to the National Physical Laboratory, Teddington, in charge of the Automatic Control Systems Laboratory in the Metrology Division, but soon moved on to become professor and head of the Department of Instrument Technology at the Military College of Science, Shrivenham. Since 1949 he has been in Canada as head of the Research Division at Ferranti Electric, Ltd., Toronto. Prof. Porter has published many papers in the fields of control systems, differential analysers and similar subjects, and is author of a monograph on servo-mechanisms. At the Imperial College he will work in close association with Prof. A. Tustin, the new head of the Department of Electrical Engineering (see *Nature*, January 22, p. 148).

Physics at the University College of Rhodesia and Nyasaland : Dr. E. Leighton Yates

Dr. E. Leighton Yates, senior lecturer in physics in the University of Sheffield, has been appointed to the chair of physics in the University College of Rhodesia and Nyasaland, Salisbury, Southern Rhodesia. Educated at the Grove Park Grammar School, Wrexham, he then studied under Prof. E. A. Owen at the University College of North Wales, Bangor, and graduated with first-class honours in physics. He did postgraduate work with Prof. Owen on X-rays, developing a high-temperature camera and investigating pure iron–nickel alloy systems. Proceeding to St. John's College, Cambridge, with a senior research award of the Department of Scientific and Industrial Research, he worked in the Cavendish Laboratory on the separation of the isotopes of lithium, boron and carbon. Dr. Yates is an excellent teacher, having lectured and demonstrated for many years and at all levels to general- and to special-degree students. During the Second World War he was largely responsible for conducting a two-year course at Sheffield in radiophysics and for developing a comprehensive practical course in radio. He has initiated extra-mural and postgraduate courses in electronics, metal physics and modern physics and given courses in building acoustics. Alone and with his co-workers, he has worked on the development of electronic control devices, the X-ray examination of metals and alloys, order–disorder transformation in $FeNi_3$, the growth of single crystals of iron, their magnetic properties under strain, and the design of an X-ray diffractometer for examining strained crystals, using a fine-focus X-ray tube. Dr. Yates's wide knowledge and experience have been always freely available to his colleagues. In the Student Christian Movement, his services have been greatly prized both in the universities and in schools.

Kossuth Prizes for Research in Hungary

The Hungarian Government has awarded a number of Kossuth Prizes for research, as follows. First-class Prizes, of £1,500 each : Academician László Rédei, for work in the field of algebra and theory of numbers, and particularly for his treatise on the Pell type of equations ; and Academician Győző Bruckner, for research on polypeptides and proteins, significant from the biological point of view. Second-class Prizes, of £1,000 each : Dr. József Baló and his wife, for research into the pathology of the blood system and the discovery of a new enzyme which digests fibrous tissue ; Dr. Péter Dénes, for an electrolytic method of producing iron and alloy powders used in the telecommunications industry ; Academician Sándor Geleji, for research in the plastic moulding of metals ; Academician Géza Hetényi, for work on the diagnosis of ulcer diseases ; Academician Árpád Kiss, for spectroscopic research on aromatic hydrocarbons and hydrated metal ions and complex salts ; and Zoltán Veress, chief engineer of the Karcag factory, for the production of special glasses, *C*9 and *G*28, for the telecommunications industry.

Scientific Research in the U.S.S.R.

Under the title "Scientific Research in Russia", the Department of Scientific and Industrial Research has issued a translation of a brief survey of recent work which appeared in *Priroda* (1954, (3) 3–10). Some initial and final paragraphs, political in character, have been omitted, and in the absence of a bibliography some references have been added to indicate Russian periodicals received in Britain which are likely to deal with the subjects mentioned. There is still a little polemic ; but the survey indicates the scope of the Russian effort. Much work has been completed on regional tectonics and the problems of magmatogenic mineral deposits. Stress is laid on investigations relating to the construction of turbo-generators, the discovery of new types of solid fuel for metallurgy, the improvement of special alloys for machine construction, and the automatic control of blast and open-hearth furnaces. In the petroleum industry use of the turbine method of boring has been extended, and the gasification of coal has been further developed, as well as the catalytic methanization of water gas and the use of steam at high pressures and temperatures. Contributions in radio-astronomy, the physics of semi-conductors, the development of seismological methods and studies of the effect of molecular structure on the rate of isotope exchange and of the mechanism of poly-condensation are noted, as well as the introduction of a new anæsthetic, promedol, claimed to be more active and less toxic than morphine. Reference is made to studies of the action of phosphatic fertilizers with radioactive phosphorus and of the use of antibiotics for the control of plant diseases; but, in general, it is stated that radioactive tracer materials have been used to a very limited extent and that use of the electron microscope has been unsatisfactory.

Visual Recording of Radiation Patterns

Several different types of apparatus have been devised for the formation of visual images of patterns of ionization ; but with the exception of those described by Prof. W. V. Mayneord and co-workers at the Institute of Cancer Research, London, they all present the final picture on recording paper or film. Prof. Mayneord uses the cathode-ray tube, and in earlier models (*Nature*, **168**, 762 ; 1951 ; and *Brit. J. Radiol*, **25**, 589 ; 1952) a persistent screen was employed. However, at low scanning speeds the persistence was found to be insufficient, and in the most recent model, which has recently been described (*J. Sci. Instr.*, **32**, 45 ; 1955), an image-storage tube is used in place of the cathode-ray tube. The picture is built up, line by line, over a long period of time, and then the complete picture is read at any later convenient time. The apparatus consists essentially of two parts : a mechanical device for moving the detector accurately over the required field of examination, and the electronic sections concerned with the detection of the radiation and the ultimate storage and presentation of the final image. The source is scanned in a series of parallel lines, and the maximum area covered can be 18 × 13½ in. The time taken for scanning a complete frame is approximately six minutes. As the apparatus described was designed primarily for the survey of radiation fields due to γ-ray emitting isotopes, the detector is a coincidence scintillation counter ; but, by the substitution of other detectors, the use of the apparatus can be extended over a wider range of radiations. Full details of the detector system and of the storage tube are given, and problems of resolution and limits of detection are discussed and illustrated by photographs. A minor modification permitting the apparatus to be used for making radiographs is mentioned, and the application of the storage principle to an X-ray spectrograph is stated to be under consideration.

Kodaikanal Observatory: Report for 1953

In the annual report of the Kodaikanal Observatory for the year 1953 (pp. 10. Delhi: Manager of Publications, 1954; As. 9 or 10*d*.), A. K. Das, the director of the Observatory, deals chiefly with the astronomical work. International co-operation with other observatories continues, and exchanges have been carried out with the Royal Greenwich Observatory, the Observatories of the University of Cambridge, Meudon Observatory, and Mount Wilson Observatory. Quarterly statements relating to solar flares were sent as usual to the Royal Greenwich Observatory and Meudon Observatory. The lists of instruments are classified under five headings: astronomical and spectroscopic instruments, of which thirty-three are catalogued; magnetic, with a total of eight; electronic, including nineteen; workshop machinery, eleven; and under other instruments, of which six are listed; but various other instruments not catalogued, such as galvanometers, photocells, thermo-relays, etc., are also available. Details of sunspot activity-spots, prominences, with the Doppler shifts of the Hα line observed in prominences, heights of prominences, etc., are shown in tabular form. Under the research training scheme sponsored by the Ministry of Education of the Government of India, two senior and two junior scholars were working in the Observatory. A list of publications—seventeen altogether—during the year is given at the end of the report.

Council for the Promotion of Field Studies: Summer Courses

A POPULAR belief that the courses organized by the Council for the Promotion of Field Studies are confined to the summer months is discounted by the issue of the programme setting out the arrangements at each of the field centres of the Council during the autumn. All the usual courses in marine and fresh-water biology, geography and general natural history, rural studies and entomology are being continued, while, in addition, each centre is arranging courses to suit more specialist interests. At Malham Tarn, for example, a short course in meteorology is being arranged during August 24–31, the directors being Dr. C. D. Ovey (University of Cambridge) and Dr. R. S. Scorer (Imperial College of Science and Technology, London). A week's course in surveying and map-making will be held at Juniper Hall during August 10–17, while courses in the identification and ecology of lichens as well as one on local mosses are being organized at Malham Tarn. A week devoted to the study of fungi is planned for Flatford Mill during September 21–28, while Dale Fort is to hold a course, limited to twelve students, on oceanography during August 24–31. The pamphlet giving the details of these courses is obtainable from the Council at Ravensmead, Keston, Kent, or from any of the above-mentioned field centres.

Forests of the Upper Nile Province, Sudan, 1862–1950

It is becoming apparent that under the Sudanization plan a large number of the British officials left in the Sudan Administration have decided to resign. In the case of the Forest Department, it is to be hoped that this will not result in a serious setback to the excellent work of the past eight years or so (see the annual report for 1951–52, reviewed in *Nature*, 173, 903; 1954). The good work of past years is further exemplified by Memoir No. 5 of the Sudanese Forestry Division, Ministry of Agriculture, entitled "Forests of Upper Nile Province, 1862–1950", by G. A. Booth (Khartoum, 1952). This brochure, which has excellent illustrations, is a most valuable piece of research work. After a reference to the evidence of Roman explorers and archæological evidence that the belt of high forest which stretched over Central Africa once extended as far north as Khartoum, Mr. Booth sets himself to examine how far in the provinces the forests have been overcut to supply the large demands for wood fuel made both by the towns and the river steamers since Sir Samuel Baker's time in the 1860's. It is too early to be able to agree with Mr. Booth's suggestion that possibly the supposed overcutting of the scattered forests to supply this growing demand for fuel has not seriously affected the forests on the areas from which the fellings were made.

University of Birmingham

In the University of Birmingham the title of reader in analysis in the Department of Mathematics has been given to Dr. B. Kuttner, and that of reader in mycology in the Department of Botany to Dr. C. J. Hickman. The following have been appointed lecturers in the University: Dr. G. W. Hutchinson (physics), Dr. T. S. West (chemistry), R. Humphreys (civil engineering), Dr. Ingeborg Gurland (education—child development) and C. J. Phillips (education—psychology).

A postgraduate course in coal preparation leading to the degree of M.Sc. by examination has been established in the University; the course will consist of lectures and laboratory and tutorial classes during the normal session, and will be followed by a project carried out on an industrial coal-preparation plant or on the pilot plant of a manufacturer of coal-preparation appliances.

In the Department of Pharmacology a grant of £1,500 a year for three years has been given by Quaker Oats, Ltd., for research into the chemistry and nutritional value of cereals.

Zoological Publications of W. D. Selensky

PROF. M. C. MEYER, professor of zoology in the University of Maine, writes to say that after considerable searching he finally obtained from abroad a copy of Waldimir D. Selensky's "Études morphologiques et systématiques sur les Hirudinées: I. L'Organisation des Ichthyobdellides", published in Leningrad (then called Petrograd) in 1915 (pp. viii + 246, 41 fig. + 8 plates; in Russian). A photostatic copy was made, and afterwards a complete translation of the text was arranged. At the time of his death in 1931 Prof. Selensky was a leading zoologist in the U.S.S.R., being head of the Parasitological Department, University of Leningrad, and his researches were devoted chiefly to the morphology, biology and the systematics of leeches, the most important contribution being the above-mentioned publication. Museum and university librarians interested in obtaining a copy of the English translation, with text-figures and plates, should write to Prof. Marvin C. Meyer, Department of Zoology, University of Maine, Orono, Maine.

Colonial Service: Recent Appointments

THE following appointments have recently been made in the Colonial Service: D. D. Campbell (agricultural officer, Uganda), principal agricultural officer, Basutoland; R. G. Heath (deputy director

of agriculture, Federation of Malaya), director of agriculture, Federation of Malaya; J. Hughes-Rice (agricultural officer, Kenya), provincial agricultural officer, Kenya; L. Johnson (economic botanist, Trinidad), senior agricultural officer, Mauritius; J. A. Sandys (agricultural officer, Nyasaland), chief agricultural officer, Nyasaland; A. H. Savile (regional assistant director of agriculture, Tanganyika), chief agriculturist, Kenya; A. I. Biggs (chemist, Department of Chemistry, Federation of Malaya), chief chemist, Department of Chemistry, Federation of Malaya; T. G. E. Gibson, assistant director of agriculture and veterinary services, Somaliland Protectorate; M. N. Harrison, plant breeder, Kenya; F. J. Smart, agricultural officer, Northern Rhodesia; L. S. Todd, agricultural officer, Uganda; B. L. Lawrence, assistant conservator of forests, Gold Coast; G. H. D. Williams, assistant conservator of forests, Northern Rhodesia; I. G. Gass, geologist, Cyprus; P. I. Morris, geologist, British Guiana; H. C. Ruick, horticulturist, Cyprus; G. H. Lampkin, research officer, East African Agriculture and Forestry Research Organization; R. Hopes, veterinary officer, Uganda.

Royal Meteorological Society: Officers for 1955–56

The following have been elected officers of the Royal Meteorological Society for the year 1955–56: *President*, Dr. R. C. Sutcliffe; *Vice-Presidents*, C. K. M. Douglas, Prof. G. Manley, Sir Graham Sutton, Dr. T. W. Wormell; *Vice-President for Canada*, Dr. D. P. McIntyre; *Vice-President for Scotland*, Sir Ernest Wedderburn; *Treasurer*, Dr. J. S. Farquharson; *Secretaries*, Dr. A. G. Forsdyke (*Librarian*), Dr. H. L. Penman, Dr. G. D. Robinson (*Editor*), R. G. Veryard.

Plant-Growth Substances: Conference at Wye College, Ashford

A third international conference on plant-growth substances will be held in Wye College (University of London), Ashford, during July 17–22. Nearly seventy people will be participating, twenty-six of whom will be from overseas countries as follows: United States, twelve; Sweden, five; Germany, four; Austria and The Netherlands, two each; and Norway, one. The following topics will be discussed (the chairmen are shown in brackets): natural auxins (Prof. H. Veldstra and Dr. G. S. Avery); chemical structure and biological activity (Dr. J. Bonner and Prof. T. A. Bennet-Clark); metabolism of auxins (Prof. P. Larsen); mode of action of auxins (Prof. L. J. Audus). Further information can be obtained from the honorary secretary of the conference, F. Wightman, Wye College, Ashford, Kent.

Conference on the Physics of Nuclear Reactors

The Institute of Physics is arranging a conference in London on "The Physics of Nuclear Reactors" during July 3–6, 1956, to be opened by Sir John Cockcroft with an address on the "Scientific Problems in the Generation of Nuclear Power". The primary purpose of the conference is to keep members of the Institute, particularly those engaged in industry, informed about recent developments in reactor physics and the cognate scientific and technical subjects, and to tell them of the problems awaiting solution. Further details will be announced in the autumn of 1955, which will include the procedure by which non-members may be considered for invitations to attend the conference.

Announcements

Dr. R. van der Riet Woolley, Commonwealth Astronomer and professor of astronomy in the Australian National University, Canberra, has been appointed Astronomer Royal at the Royal Greenwich Observatory in succession to Sir Harold Spencer Jones, who is to retire on December 31.

The Paris Academy of Sciences has elected Lord Cherwell, Dr. Lee's professor of experimental philosophy in the University of Oxford, and Prof. G. Cassinis, director of the Polytechnic of Milan, to be *correspondants* for the Sections of Free Academicians and of the Applications of Science to Industry.

Dr. F. P. Bowden, reader in physical chemistry in the University of Cambridge, has been awarded an Elliott Cresson Medal by the Franklin Institute, "for his extensive experimental investigations of the friction between solid surfaces, investigations which combine simplicity and clarity, and for his findings regarding the detailed nature of the processes involved when one metal slides over another".

Sir James Chadwick, master of Gonville and Caius College, Cambridge, and formerly Lyon Jones professor of physics in the University of Liverpool, has been elected an honorary Fellow of the Institute of Physics.

The Oceanographical Institute of Monaco has awarded its Commemorative Medal of Prince Albert I of Monaco (the Manley-Bendall Prize) to Dr. J. N. Carruthers, director of the National Institute of Oceanography [of Great Britain], for his distinguished work in physical oceanography.

General Matthew B. Ridgway, who recently retired from his post as chief of staff of the United States Army, has been appointed chairman of the Board of Trustees of the Mellon Institute of Industrial Research, Pittsburgh, Pa., with the responsibility of being the chief administrator of the Institute as well as acting for the Trustees in promoting their plans to expand the Institute's staff and scientific programmes. Dr. E. R. Weidlein will continue in his post as president of the Institute.

Dr. S. Whitehead, director of the Electrical Research Association, has been re-elected chairman of the Committee of Directors of Research Associations for a further year.

The triennial award of the above Prize and Medal has been made by the Council of the Institution of Electrical Engineers to Mr. D. McDonald for his paper on "The Electrolytic Analogue in the Design of High-Voltage Power Transformers". The prize, which consists of a bronze medal, a certificate and about £20 in money, is awarded for the best paper on a professional subject published by the Institution during the period of the award; but only authors who are corporate members less than thirty-five years of age are eligible.

The European Molecular Spectroscopy Group is meeting in the University of Oxford during July 7–11.

The Nutrition Society is arranging a symposium, to be held in the Physiology Laboratory, University of Oxford, during July 8–9, on the nutritional work of the United Nations Food and Agriculture Organization, the World Health Organization, and the United Nations Children's Fund. Further information can be obtained from Dr. H. M. Sinclair, Laboratory of Human Nutrition, 10 South Parks Road, Oxford.

NEW VISCOSE RESEARCH LABORATORY OF COURTAULDS, LTD.

THE new viscose research laboratory of Courtaulds, Ltd., has recently been completed at Coventry and was on view to visitors during the week commencing May 16. This is the latest, and at present the largest, of the Company's six research laboratories. Together with its associated pilot plants, the laboratory will be devoted almost entirely to research and development work on the manufacture of regenerated cellulose fibres by the viscose process. Broadly speaking, its main objects are to effect major improvements in the properties of the fibre and to develop improved methods of manufacture. Its activities will range from fundamental to large-scale technological work in a broadly based programme.

The man-made fibre industry operates to-day on a very large scale; it is not generally realized that it supplies nearly 20 per cent of the world's textile requirements. Of its annual world output of some two million tons, about 80 per cent is produced by the viscose process. Originally the only product of this process was continuous-filament textile yarn. The viscose process has, however, proved remarkably flexible; the range of its products has progressively widened, and to-day includes special high-tenacity yarns used mainly for industrial purposes and a number of different types of staple fibre. With the expanding range of outlets, a host of new problems has arisen in developing fibres specially suited to particular end uses.

The raw material of the industry is cellulose, predominantly in the form of highly refined wood pulp. It is abundant and relatively cheap, as are the other major chemicals employed. The industry is therefore in a position to expand its output to keep pace with the world's ever-increasing demand for textiles.

The processes involved in the production on an industrial scale of regenerated cellulose fibres with properties suited to their various uses are complex and inherently difficult to investigate; even after fifty years of activity the industry still presents many problems of considerable depth which remain to be solved. In the early days, considerable progress was made despite the lack of understanding of the background science; but the time has now come when progress will depend increasingly on a thorough understanding of the physical and chemical changes which take place during the production of the viscose solution, its extrusion into a coagulating bath and the subsequent regeneration of cellulose in the form of filaments with properties suited to their end use. A major aim of the new research laboratory will be to provide this essential background.

In the field of textile science it is not yet possible to describe satisfactorily in terms of measurable parameters many of the properties of fabrics such as drape, handle or durability, which control both their functional behaviour and their appeal to the customer. It remains also to relate these textile properties in a satisfactory manner both to the details of fabric construction and to the properties of the fibres from which they are made. The man-made fibre industry has always striven to produce fibres with the most useful properties, and, for an intelligent approach to this problem, it is necessary to relate these properties to the chemical nature of the building unit—the linear polymer molecule—and to the fine structure and morphology of the fibre. Only by the fundamental study of these problems can technological progress be firmly based, and the work of the individual sections of the new laboratory is integrated with these general aims in view.

The raw material, wood pulp, is being studied in relation to its subsequent behaviour in the viscose process and to the properties of the ultimate fibre. Some of this work is carried out in collaboration with pulp producers, and it is an interesting example of the power of co-operative effort that it has already produced useful results in a difficult field of investigation.

The extrusion or spinning of viscose solution through the fine holes of a spinnerette into an acid coagulant produces filaments of regenerated cellulose by a variety of chemical and physical processes which occur with great rapidity. Persistent physico-chemical study is slowly clarifying the picture; but the basic research tool is undoubtedly the single-end spinning machine. Direct investigation of spinning phenomena based upon the indications of more fundamental work yields positive information about the physical and chemical conditions which control the formation and properties of the filament. Every attempt is made to build the necessary basic properties of strength, flexibility and elasticity into the fibre. In addition it is possible, by the incorporation of extremely fine dispersions of white or coloured pigments into the viscose solution, to modify the lustre of the yarn and to produce a wide range of extremely fast colours. This latter development is particularly important in the field of staple fibre where many of the end uses call for extreme colour fastness and where additional effects can readily be obtained by blending fibres of different colours.

The properties of regenerated cellulose fibres can also be modified by chemical after-treatment. This is very largely the province of the organic chemist who is able to control the degree of swelling in water by means of cross-linking reactions, to confer water repellency, the power of adhesion to rubber and many other specific properties by the use of suitable reagents.

In order to facilitate the rapid utilization of research results in production, the laboratory is associated with extensive pilot plants and has a large engineering section.

The new building, which is steel-framed with floors and roof of pre-cast concrete beams, consists of a basement and four floors of laboratories in the main block. An office wing links it to an existing administrative block. The 'Cotswold grey' brick façade overlooking the main Foleshill Road contrasts with the extensive glass area of the laboratory windows on the other three sides of the building, and insulates the working areas from street noises; at the same time a maximum amount of light reaches the working areas.

On each floor the laboratories are situated on both sides of a central corridor. They are based on a standard module of 25 ft. 6 in. × 11 ft. 9 in. Pro-

vision is made for supplying all services to every module so that the internal layout can readily be modified to suit changing requirements. The services are distributed by horizontal mains running at high level throughout the basement, with branches rising up vertical ducts on each side of the central corridor. From these vertical risers branch-pipes are taken through shallow floor-ducts to the laboratory benches. The services include high- and low-pressure steam; electrical power; cold, hot and demineralized water; coal gas; compressed air and vacuum; and brine for cooling. The building is heated and ventilated by warmed and filtered air distributed from a plant in the basement by a plenum system which is directed into three zones per floor; each zone has a subsidiary heater which is under local thermostatic control. Special air-conditioning is provided for the textile research and testing laboratories where constant temperature and humidity conditions are required.

The new laboratory was designed by the Company's architects and engineers in consultation with the scientific staff and completes the post-war development of Courtaulds' viscose research facilities. Major extensions of the Company's other laboratories are in progress.

MICROWAVE AND RADIO-FREQUENCY SPECTROSCOPY

FARADAY SOCIETY MEETING

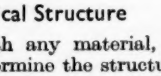
A THREE-DAY meeting of the Faraday Society was held in Cambridge during April 4–6, when the subject of the discussion was "Microwave and Radio-frequency Spectroscopy". The president, Prof. R. G. W. Norrish, opened the meeting, at which more than two hundred members were present, by welcoming more than a hundred British and foreign guests; these included contributors from Denmark, France, Germany, the Netherlands, Switzerland, the United States and the U.S.S.R.

Ten years ago the subject of microwave and radio-frequency spectroscopy embraced essentially only one experiment, namely the direct detection of the inversion frequency of ammonia by C. E. Cleeton and N. H. Williams. Consequently, the majority of members of the Society were not taught anything about low-frequency spectroscopy during their student days. Since the techniques involve a considerable amount of advanced physics and electronic engineering, most members had not had an opportunity of gaining first-hand experience and, as a consequence, were very glad of the opportunity of learning directly from the pioneers and of judging for themselves the possible applications of the new techniques to their own individual interests. They learned that a wide range of topics was concealed under the narrow-sounding title, and there were important contributions to the following subjects: chemical structures, geometrical structures of molecules, electronic structures, thermodynamics, equilibria, molecular kinetics, electrochemical kinetics, botany, biology and astronomy.

In the formal sessions, thirty papers were presented and discussed. Since a summary which would do full justice to these would either be very lengthy or would assume the reader to possess a detailed background knowledge, the rest of this article will enumerate the results presented without detailed reference to the manner in which they were obtained. Besides the original work, there were several contributions which were wholly, or in part, of an introductory or review nature. In the latter class were the accounts of nuclear properties (H. C. Longuet-Higgins), microwave or pure rotation gas spectroscopy (W. D. Gwinn; W. Gordy), non-resonant electron absorption in flames (T. M. Sugden), paramagnetic electron resonance in compounds with metal ions (J. H. E. Griffiths), free radical electron resonance (G. E. Pake), nuclear magnetic resonance (H. S. Gutowsky), and quadrupole resonance in solids (H. G. Dehmelt).

Chemical Structure

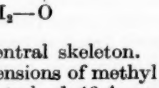
When presented with any material, a chemist's primary task is to determine the structural formula. The structure of diketene has been established to be



by P. T. Ford and R. E. Richards from the proton resonance of the solid, and this has been confirmed by entirely distinct evidence, from the chemical shifts in the liquid, presented by H. S. Gutowsky. The latter type of experiment is relatively rapid and easy to interpret qualitatively, and already a table of characteristic shifts has been established and is likely to have many applications analogous to those of a table of characteristic infra-red absorption frequencies. Also, elegant proofs of the correctness of the bridge structures for diborane, for the pentaborane pyramid, and for the decarborane basket, were given by J. N. Shoolery using the nuclear 'double resonance' technique. A rather different identification of a structural unit is that of E. E. Schneider, who used the electron resonance of the free radicals obtained by the degradation of polymers by irradiation with X-rays; with polythene the evidence points to predominantly $-CH_2^{\cdot}$ and with 'Teflon' to $-CF_2^{\cdot}$ ends to the free radical chains. Another experiment is that of R. R. Livingston *et al.*, who identified hydrogen atoms trapped in phosphoric acid, sulphuric acid and perchloric acid on irradiation with γ-rays at 77° K.

Geometrical Structure

For compounds of established chemical structures, a chemist is interested to discover the geometrical structure, that is the bond distances and angles, and microwave gas spectroscopy is a powerful tool for this purpose. W. D. Gwinn reported that trimethylene oxide,



has a strictly planar central skeleton. J. Sheridan *et al.*, reporting the dimensions of methyl diacetylene, found the CH_3—C bond to be 1·46 A. and the central single bond between the two triple bonds to be 1·37 A., and these figures show a marked shortening with respect to the C—C bond in ethane, which is 1·54 A. Another short C—C bond is that reported by B. Bak *et al.*, who found 1·44 A. for the $C_{(3)}$—$C_{(4)}$ bond in furan. Nuclear resonance can be used for locating hydrogen atoms, and E. R. Andrew and D. Hyndman have used it for showing that in the solid state the hydrogen atoms of urea lie in the CON_2 plane. The accuracy of the method is shown by the results of

L. E. Drain, who showed that in ammonium fluoride crystals the N—H distance is 1·04 A. and the H—F distance 1·64 A., which is in complete accord with the X-ray value of 2·67 A. for the N—F distance and shows that the nitrogen, hydrogen and fluorine atoms are collinear. Structural information of another type is shown in the work of B. M. Kozyrev, who showed the electron resonance of Cr^{+++}, Mn^{++}, Cu^{++}, etc., in solution to be very similar to that of the hydrated salts, and so the short-range order in the hydration sheaths must be very similar in the two states.

Electronic Structure

After the atomic positions have been settled, the chemist's next questions concern the electron distribution, and the new techniques give four new types of experimental evidence with which to supplement the energies, dipole moments and polarizabilities that have hitherto provided the major experimental checks on proposed wave functions. However, the newer quantities all refer to interactions with the nucleus and are most sensitive to the electron distribution near the nucleus, a region for which otherwise satisfactory wave functions have not previously been tested. In particular, a difficulty arises with the overlap integral required in the normalization of a molecular wave function constructed from two atomic functions, since this must be set to zero for satisfactory interpretation of the new data. Consequently, although the experimental quantities are accurately known, the interpretation has not reached a similar precision and is still a matter for individual opinion. The most often measured quantity is the second derivative of the electric potential at the nucleus, $\partial_2 V/\partial z^2$, which is obtained from nuclear quadrupole couplings. Both W. Gordy and B. P. Dailey discussed the interpretation and showed that information could be obtained about the degree to which the valency p atomic orbitals are used in chemical binding and also about the relation of ionicity to electronegativity differences. The zero coupling found for cæsium chloride vapour confirms the wholly ionic nature of the bond, while the large coupling in a chlorine molecule confirms the essentially $3p_z$ character of the atomic orbitals involved in the bond. Many compounds, including methyl chloride, show an intermediate coupling for the chlorine nucleus; but the amount of reduction due to ionic character and the amount due to sp hybridization depend on the choice of assumptions, since it is impossible to obtain two unknowns from one numerical observation.

The second experimental quantity is $\psi(0)$, the value at an atomic nucleus of the wave function of an unpaired electron in a free radical or a metal ion. $\psi(0)$ is only non-zero for an s atomic orbital; but unpaired electrons are normally in p, d or f orbitals. Nevertheless, a coupling is found even in these cases, and it must be the consequence of admixture of a few per cent of s character through configuration interaction, a complication which is omitted in many approximate theoretical calculations made for other purposes. Thus it is at present difficult to give a numerical value for the proportion of time an electron spends at each atom. But it is clear, from the results presented by G. E. Pake, that in triphenyl methyl the unpaired electron is principally on the central carbon atom, whereas in the isoelectronic triphenylamine positive ion the greater attraction of the nitrogen for electrons ensures that it is surrounded by electron pairs and the unpaired electron is relegated to the phenyl rings.

If the central atom is a metal ion surrounded by an octahedral complex in a crystal, a more detailed treatment is possible, and this was outlined by J. Owen. He showed how d orbitals of the central atom may accept a pair of electrons from a chlorine ion, water molecule or other group in the complex shell, and how in exchange the unpaired electron from the metal resides partly on the outer group. The new bonds to the metal may be σ bonds formed through endwards overlap of the d orbitals, or π bonds formed through sideways overlap. An example of the σ type is $[Cu(H_2O)_6]^{++}$, where the unpaired electron is present to 2·3 per cent on each water molecule, and an example of the π type is $[IrCl_6]^{-}$, where the unpaired electron is 5 per cent on each chlorine ion. For the trans-uranic elements the susceptibilities and the resonance experiments, described by B. Bleaney, show that the $5f$ rather than the $6d$ shell is used for accommodating unpaired electrons and that one of the $5f$ orbitals is probably involved in bonding to the oxygen in the UO_2^{++}, NpO_2^{++} and PuO_2^{++} ions. C. H. Townes discussed the other interactions and showed that nitric oxide is best described as 65 per cent $N=O$ and 35 per cent $N^-\equiv O^+$; he further indicated the principle by which magnetic effects could be used for determining absolutely the sign of an electric dipole moment.

Thermodynamics, Potential Barriers and Equilibria

After a chemist has fully determined the molecular structure of a compound, he may be interested in its thermodynamic properties in bulk, and in this connexion P. T. Ford and R. E. Richards showed the barriers opposing rotation of the BH_4^- ion to be 2·4, 3·8 and 3·9 k.cal./mole in the sodium, potassium and rubidium salts, respectively. Also using nuclear resonance, J. A. S. Smith has been able to relate the intermolecular motions in 'Teflon' to its λ-point transitions. A value of only 6·00 cal. for the six-fold internal rotation barrier in nitromethane, CH_3NO_2, was reported by W. D. Gwinn from the microwave spectrum, and this value is reduced to 5·17 cal. in CD_3NO_2, where the bending vibrations have a smaller zero-point amplitude. These very low values suggest that the three-fold barrier opposing each oxygen is close in shape to a pure cosine function, so that the barriers for two oxygens cancel almost exactly. This adds confidence to the acceptance of the many barriers previously obtained from specific heats on the assumption of a cosine shape. Barrier information was also obtained from nuclear resonance by R. A. Ogg and J. D. Ray, who found that in the hydrogen bridge compound $Al(BH_4)_3$ each BH_4 unit is capable of rotation by means of a tunnel effect at a frequency greater than 10^8/sec., even though the barrier height is above 14 k.cal.

Equilibria were discussed by T. M. Sugden, who described how the non-resonant microwave absorption by the electrons in flames leads to a study of reactions such as

$$Li + OH \rightleftharpoons LiOH$$

for which the heat of reaction is 102 k.cal./mole, and also to the less-expected reaction

$$CaO + H_2O \rightleftharpoons CaOH^+ + OH^-$$

for which the heat is 96 k.cal./mole. From related experiments, F. M. Page has found the electron affinity of the hydroxyl radicals to be 65 ± 1 k.cal./mole.

Kinetics

In cases of known equilibria, the chemist is interested in the rates of attainment of such states, and W. A. Anderson and J. T. Arnold were able to show that in extremely pure alcohol the exchange of protons between molecules occurs less than once per second, but that with 10^{-5} gm.-ions/l. of H^+ present the nuclear resonance lines broadened, indicating the reaction

$$[C_2H_5OH_2]^+ + C_2H_5OH \rightarrow C_2H_5OH + [C_2H_5OH_2]^+$$

to have a mean time between exchanges of about 0·2 sec. There was also mention of an unusual type of oxidation-reduction reaction, namely, the exchange of an electron between naphthalene and its negative ion

$$C_{10}H_8^- + C_{10}H_8 \rightarrow C_{10}H_8 + C_{10}H_8^-,$$

for which S. I. Weissman *et al.* found a second-order rate-constant of 10^{-5} l.mole^{-1} sec.$^{-1}$ at 30° C. from electron resonance experiments.

This covers the major divisions of chemistry with the exception of preparative work, and even R. A. Ogg's postulate of $Al_2B_4H_{18}$ formed reversibly on heating $Al(BH_4)_3$ might be classed in this field. For the botanist and biologist, G. E. Pake *et al.* have shown that germinated foxglove seedlings (digitalis) contain free radicals which were absent in the ungerminated material, and that free radicals are also present in metabolically active liver and kidney tissues. D. J. E. Ingram and J. E. Bennett have investigated phthalocyanine and hæmoglobin metal ion resonances and showed these to be sensitive to structure. Finally, as regards this account, there was a description of a molecular oscillator by N. G. Basov and A. M. Prokhorov which should be stable to better than 1 in 10^9, that is, 30 msec./year. Such an oscillator coupled to a clock mechanism should be a useful tool for astronomers; C. H. Townes reported that initial experiments have approached this figure for the stability.

Thus it can be seen that not only must the Faraday Society be congratulated on a most successful meeting worthy of ranking beside the best of its predecessors, but also that it must be congratulated on a brave and opportune choice of subject.

D. H. Whiffen

SCIENCE AND BRITISH RAILWAYS

THE part that science can play in the improvement of railways is not so much in the production of, say, better locomotives, as in the impartial study of a great variety of problems arising in the railway business as a whole. Some of these problems and the way they are approached were described by T. M. Herbert, director of research, British Railways, in a recent lecture to the Manchester Literary and Philosophical Society (*Manchester Memoirs*, **95**, No. 8). Of the two hundred scientific staff who make up the research department of British Railways, not more than a quarter are engaged on definite research projects, the others being concerned with some form of scientific service requiring the employment of staff with a scientific training and outlook.

The true function of a railway is to provide a transport service for passengers and freight, and to move them from point to point as safely, as efficiently and as cheaply as possible. It is only an incidental to providing such service that the railways need conduct a vast engineering business in the manufacture of such things as locomotive and rolling stock. Only about one-third of the annual expenditure is devoted to the engineering side of the business, that is, the construction and maintenance of locomotives and rolling stock, the maintenance of buildings, structures and track, etc.

It has been suggested that research on equipment and materials used by railways could probably and perhaps better be carried out by the industry concerned with the manufacture of such equipment and materials. There is some truth in this belief. A railway is so much concerned with the subsequent performance, reliability and maintenance of its physical equipment, however, that much of its research and study can only be carried out by railway staff on the equipment and material during its actual life.

Another argument for the existence of a scientific service within the railways is that it ensures that the results of scientific development in the universities, other industries and other fields are not ignored.

The varied nature of the activities and problems of the railways provide for a scientific service employing chemists, engineers, metallurgists, physicists, mathematicians, as well as those trained in economics and statistical methods. British Railways are almost unique among railway administrations in having grouped their scientific resources into a single department; it has made possible the formation of a sizable unit in place of a number of small groups which would probably have been less effectively staffed and equipped.

The Research Department of the Railways comprises three main groups, the first consisting of the engineering, metallurgical and physical laboratories which are at Derby, the second consisting of a group known as Chemical Services, and the third a small group known as the Operational Research Division. The first group is almost entirely concerned with research proper, some of it carried out in the laboratory but a good deal of it in the field; the second group provides chemical service from a number of laboratories located throughout the country at important railway centres, with specialized laboratories dealing with protective coatings, corrosion, building materials and textiles. The Operational Research Division is centred in London; but its staff operates wherever required. The annual budget amounts to about a quarter of a million pounds. There is a smaller but similar unit within the London Transport Executive, and the Docks and Inland Waterways Board of Management.

The work of the chemist consists of the examination of materials used by the railways; the laying down of specifications; the examination of new materials offered by industry and services of a more specialized nature like the chemical and bacteriological control of water supplies. There is also a de-infestation service, in respect of premises, vehicles, and stored products such as foodstuffs, tobacco, hides and skins,

wool and other fibres. The chemists also perform important and essential advisory work in connexion with the classification of rail traffics for charging purposes, on safeguards in their conveyance and storage, and in the investigation of alleged damage to goods in transit. Other typical examples of chemical investigations are those into the materials used in the making of railway detonators and into the suspected deterioration in old brickwork.

Problems arise in the physical study of the ventilation and heating of passenger vehicles. The fully air-conditioned coach with sealed windows is scarcely justified in our climate, and the tradition of the open window dies hard. Nevertheless, the present type of sliding ventilator seems to be a reasonable compromise, and extensive air-flow explorations and wind-tunnel tests were conducted when it was adopted. The heating problem is closely associated with a proper knowledge of the air-flow within a compartment or coach; but there is an inherent difficulty in heating the end of a long train. The passage of steam through a long, and by no means straight, pipe from the engine to the fifteenth coach involves the study of a rather complicated heat-balance problem.

The Physics Division is concerned with a very diverse series of problems. Some of these have been concerned with the analysis of data obtained in the course of engineering investigations, including locomotive testing and train resistance studies. Others have formed a direct or an alternative attack on problems involving vibration, elasticity and heat transfer. Among the vibration problems was the study of the behaviour of a machine for carrying out fatigue tests on full-size rails, in which the rail carried a number of attached masses on one of which acts a harmonically varying force.

During the past few years, the investigation of the relative merits of the vacuum and air brake for freight trains has occupied much attention from the research engineer. The fitting of continuous brakes would greatly speed up the whole tempo of railways operating, by closing the gap between the speed of passenger and freight trains, thus reducing delay and increasing line capacity. With very long trains, which may be either empty or loaded, there are serious technical problems in ensuring that the brakes are applied to each wagon as simultaneously as possible, and in releasing the brakes quickly after a full brake application.

The largest single group of engineering research studies relate to the track. One large-scale experiment is in hand to try to assess the optimum depth of ballast, and important work is also in hand to determine the lateral resistance of ballast, which becomes of special moment in the case of long-welded rails. The behaviour of concrete sleepers of various designs and methods of attaching the rails to them are also being continually studied at the present time.

There is also the problem of the rails themselves. Rails in Britain fail primarily by fatigue in the top fillets or at the bolt holes at the joints, and laboratory equipment has been developed for fatigue testing complete rails.

The other aspect of the rail problem is more of a metallurgical character. In course of time rails are replaced because the section, and therefore the strength, has been reduced by wear and corrosion. On the running surface of the rail these two influences combine in producing loss of metal from the rail head. In Britain, with its relatively humid climate, corrosion occurs at the initial corrosion-rate between the passage of successive trains, and by improved methods of wear measurement and axle counting much new data are being accumulated on the problem.

The operational research teams have studied such subjects as the logical basis for bonus payment systems, the present-day facilities for conveying passengers' luggage, and the proper quarter on which to place responsibility for the issue of station stores. Other work of great importance has been the study of the use of locomotive coal, both in hauling trains and during standby periods.

ROYAL TECHNICAL COLLEGE, GLASGOW

REPORT FOR 1953–54

THE report on research during the session 1953–54 at the Royal Technical College, Glasgow*, gives a brief conspectus of research pursued in the various departments which conduct research programmes. Under each of these departments is given a list of theses submitted for higher degrees and a list of publications in which the titles are amplified by brief abstracts or annotations.

Research in the Department of Mathematics has been concerned with gas dynamics, the applications of blanket transforms in statistics, and the applications of new complex-variable techniques in problems arising in elasticity. In the Department of Natural Philosophy, work has continued in collaboration with the Technical Chemistry Department on the effects of polishing and annealing on the surface structure of finely ground quartz and vitreosil. In geophysics reasons have been sought for the sudden increase in electrical conductivity, to metallic character, within the earth's mantle at a depth of about 700 km. Research continued on the properties of both metallic and non-metallic evaporated films, and an electron-microscopic study was made of the hydrochlorination of natural (*Hevea*) rubber and various synthetic polyisoprene lattices covering a tenfold range of particle size. In the Department of Chemistry research on natural products continued as a major activity in the organic laboratories, while in the physical and inorganic laboratories the study of the photochemical properties of solutions of ferric iron continued and the critical micelle concentrations of some long-chain detergents were being measured by colorimetric and fluorimetric methods.

Research in the Department of Technical Chemistry was concerned with three main fields: the properties and processing, particularly dyeing, of natural and synthetic high polymers; the pyrolysis of organic substances; and the surface chemistry of finely divided solids and of liquid/gas and gas/liquid dispersions. The research programme of the Department of Metallurgy continued to be concerned chiefly with slag/metal relations; but interest in powder metallurgy was extending.

The Department of Civil and Mechanical Engineering undertook, as in previous years, a wide range of short-term investigations for local industries, while in the Department of Electrical Engineering, besides

* Royal Technical College, Glasgow: Report on Research, Session 1953–54. Pp. 40. (Glasgow: Royal Technical College, 1954.)

the main work on high-voltage and heavy-current phenomena, postgraduate work in electronics has developed and a new line of research on non-linear servo-mechanisms was commenced. The Department of Mining Engineering has investigated the resistance to airflow of different roadway linings and tubs at varying spacings, and in the Department of Architecture, Town Planning and Building investigations related to timber structure have been made, in addition to postgraduate studies and planning reports on the history, present condition and development of Campsie, Cumbernauld, Galston, Kilmacolm, Uddingston and St. Andrew's Square, Glasgow. Research activities of the School of Pharmacy and School of Bakery fall into five main groups: pharmaceutical and pharmacological; pharmaceutical chemistry; microbiological; biological; and biochemical.

NEW MATERIALS AND PROCEDURES FOR GENETIC STUDIES OF YEASTS*

By Dr. LYNFERD J. WICKERHAM

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UP to the present, the only species of *Saccharomyces* which have been hybridized are a few that are closely related to *S. cerevisiae*, the type species of the genus. *Saccharomyces*, as defined by Lodder and Kreger-van Rij[1], is composed of several groups of species, some being very different from *S. cerevisiae*. One group consists of *S. lactis*, *S. fragilis* and *S. marxianus*, and species which have been described under the names of *Zygosaccharomyces ashbyi* and *Z. dobzhanskii*. I intend to place these species and several others in a new genus called *Dekkeromyces*, named in honour of Dr. N. M. Stelling-Dekker.

The low average germination of ascospores in strains of *Dekkeromyces* precludes the usual micromanipulator procedures; but hybridization by a very simple procedure has been successful. Cells of the two species to be hybridized are mixed on a slant of malt-extract sporulation medium (for composition of media, see ref. 2) and incubated for ten days at 25° C. Cells on the lower part of the ten-day-old agar-slant culture are mixed thereon and streaked on a second slant. A total of four similar serial transfers is sufficient to produce hybrids if the strains are compatible.

Two methods are used for separating the hybrids from the parent cells. The first is based on the fact that, in most species of the anticipated genus *Dekkeromyces*, strains vary widely in the amount of red pigment which they produce on malt extract–yeast extract agar and on morphology medium. When weakly chromogenic strains are mated, strongly pigmented hybrids are produced. The red pigment is related to pulcherrimin[3], and I have found it to have antibiotic activity. The pigmentation of the hybrids permits their ready recognition.

In the second method, species differing in the carbon sources which they assimilate are hybridized. For example, one parent may assimilate maltose, the other lactose, and some of the hybrids will assimilate both. The mixture of hybrids and parents are grown in a series of shaken flasks containing maltose as the only source of carbon (except for a trace in the vitamins of the medium), thus eliminating the parent which cannot assimilate maltose. Then cells from the last maltose flask are transferred serially in lactose medium, which eliminates the parent that does not assimilate lactose, thus yielding a culture of the hybrids.

Species have been hybridized which are very different in their sexual characteristics. For example, *S. lactis*, which is heterothallic and completely haploid, has been hybridized with *Z. ashbyi*, which is homothallic and predominantly diploid, to yield hybrids some of which are exclusively diploid (or possibly triploid). Some of the hybrids are homothallic, some are heterothallic, and others produce only a few, infertile ascospores.

Physiologically, a maltose fermenter (*Z. dobzhanskii*) has been mated with a lactose fermenter (*S. fragilis*) to produce the first ascosporogenous yeasts known to ferment both these sugars. *Saccharomyces fragilis* is unable to attack the alpha-glucosides maltose, melezitose or alpha-methylglucoside; but it ferments lactose. *Zygosaccharomyces dobzhanskii* ferments alpha-glucosides but has no action on lactose. Hybrids produced by these two species ferment the alpha-glucosides less actively than does *Z. dobzhanskii*, and the hybrids produce variants which range downward in activity, with some having no ability to ferment and almost no ability to assimilate alpha-glucosides. Yet all the hybrids and their variants ferment lactose.

Persons interested in studying genetics of these species may obtain appropriate strains from the Northern Utilization Research Branch, Agricultural Research Service, U.S. Department of Agriculture, Peoria, Illinois.

* Substance of a paper presented at the annual meeting of the Mycological Society of America, September 3–9, 1954.

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LONG-DISTANCE PLANT DISPERSAL IN THE NORTH POLAR REGIONS

By Dr. NICHOLAS POLUNIN

ONE of the most familiar and provocative phenomena in plant geography is the occurrence of some species at far-flung points between which they are, or at least appear to be, wanting. Sometimes there are no suitable habitats in the intermediate positions, sometimes the habitats are there but the plants are lacking, and all too often careful exploration has shown that the plants in question occur in intermediate situations after all—that the supposed disruption in their range was exaggerated or even non-existent. This is especially the case with diminutive plants and minor taxa that are easily overlooked.

Such range-disruption, whether actual or only supposed, has engendered some of the most active theorizing, and has stimulated much of the most

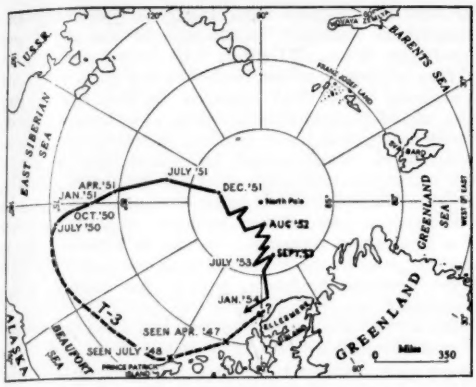

Fig. 1. Drifting of *T*-3 in the North Polar Basin

lively discussion, in all biogeography. It has been brought with particular force into arguments concerning such hypotheses as those of continental drift, perglacial persistence, and land-bridges. Indeed, there can scarcely be a major ocean that has not been hypothetically bridged by some enthusiastic biogeographer on the basis of the present-day disrupted range of the biota inhabiting its peripheral land-masses. To those who favour such hypotheses, long-distance dispersal is, of course, anathema, as it is apt to remove the very bases of their contentions.

Without denying the possible validity at some times and places of one or more of these hypotheses seeking to explain disrupted ranges in terms of 'historical' situations or events, it may be pointed out that our evidence for long-distance dispersal taking place in various regions and circumstances is mounting considerably in diversity and weight. Moreover, it should be remembered that the dispersal at any time of even a single disseminule of a hermaphrodite species to a new spot may, if it is followed by successful germination and ecesis, lead to the full establishment of the species at that new spot, which may in its turn become a centre for further colonization. Such 'saltatory' migrations over great distances of what are naturally pure strains may actually be the origin of the supposedly 'relict' populations 'depleted in biotypes' which advocates of persistence have called 'conservative'.

Whereas there are various ways in which plants are known to be dispersed in the Arctic, the case which has engendered the present communication is of a very special nature. In July 1953, Mr. A. P. Crary, of the Geophysics Research Directorate, Air Force Cambridge Research Center, found on the ice-island *T*-3 an almost flat, mat-like 'tussock' of moss about 24 cm. in diameter which he gave to me. Although dry and upside down when found, "lying near the edge of a melt stream on bare ice" (Crary *in litt.*), the tussock was greenish on its morphologically upper surface. It proved to be made up exclusively of the predominantly arctic species *Hygrohypnum polare* (Lindb.) Broth., being identified by Prof. William C. Steere, of Stanford University. Unlike all the other macroscopic botanical material collected on *T*-3, this specimen turned out to be alive[1]. Thus a portion of it, when moistened and kept under a bell-jar, soon lost its green colour and after ten days still gave no evident sign of life, being soggy and brown; yet after eighteen days the younger shoots were observed to be putting out tender laterals, and after less than four weeks the whole was a vivid green with new growth. It survived in this vegetative condition for several months, until the early summer of 1954, but then became lost in a move of my main laboratory from Harvard to Yale. Later attempts to revive other pieces of the same tussock have so far proved unavailing.

At the time when this moss was found, *T*-3 was floating in lat. 85° 41′ N. and long. 96° 20′ W., far out in the Polar Basin. So this seems to be much the most northerly collection of a living macroscopic plant ever made, being indeed from far north of the northernmost land in the world; and whereas it might be argued that its chances of ever reaching land, if it had been left alone, and of becoming re-established, would have been infinitesimally small, nevertheless they cannot be entirely ignored, having regard to the manner in which ice-islands are now known to float about the Arctic and, at least when smaller, even come so near to land that it is quite conceivable such a light and dry tussock might be blown back to effect migration. Thus, for example, it is computed that *T*-3 must have floated, ignoring minor lateral movements, at least some three thousand miles (4,800 km.) since becoming separated from the remaining shelf-ice of northernmost Ellesmere Island. There it apparently originated, and there the tussock of *Hygrohypnum polare* was presumably blown or washed from the land on to the adjacent shelf-ice before part of this last broke away to form *T*-3. It is even possible that the ice-island, and with it the moss, may have floated twice that distance around the Arctic Ocean since breaking loose—probably in 1936 or one of the ten subsequent years[2].

The possibility has been considered that this moss might have grown on *T*-3, for example from an airborne spore which alighted on it when it was floating far out in the Arctic Ocean. But although moss spores are well known to be transported in the atmosphere to remote regions, and some protonemal growth has been observed on snow and ice[3], there is no evidence that development can proceed to leafy plants in such circumstances, much less reach the considerable dimensions of this specimen. Moreover, no macroscopic form of life has been found on the mixed morainic or dirt or other deposits on the island, and the crumbs of inorganic material enclosed

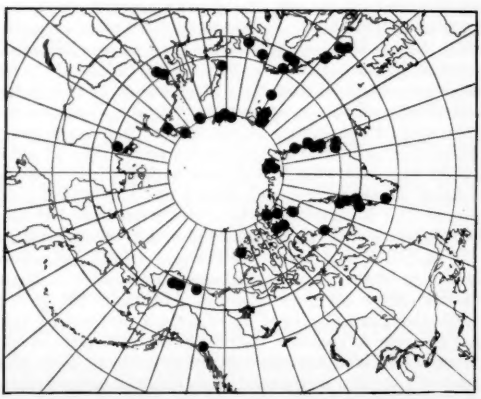

Fig. 2. Known geographical distribution of *Hygrohypnum polare* (Lindb.) Broth.

in the tussock appeared to be of alluvial origin, so there seem to be good reasons for discounting such a suggestion. Finally, Mr. A. P. Crary, who has lived for considerable periods on *T*-3, making all manner of scientific observations, considers it inconceivable that this moss tussock could have grown on *T*-3 or that it could have reached the island after its separation from the land. For, on one hand, on *T*-3 the temperature scarcely rises above 0° C. even in the warmest month and not even *small* growths of mosses are to be found, and, on the other, the jammed-up ice skirting the northernmost coasts commonly prevents a close approach to land and its roughness impedes travel of at all heavy objects by blowing. Nevertheless, other ice-islands—and this could in time apply to *T*-3—have been observed very close to land in the channels of the Canadian Arctic Archipelago[4], making it by no means inconceivable that this tussock of moss might ultimately have reached land and effected migration if it had been left alone and had remained viable.

Fig. 1 shows the presumed (broken line) and known (solid line) route of *T*-3 in the North Polar Basin since observations commenced in 1947, the 'July '53' spot in lat. 85° 41′ N. and long. 96° 20′ W. indicating where the living moss was gathered. Data for this sketch-map were kindly supplied by the Geophysics Research Directorate of the Air Force Cambridge Research Center. The known distribution of *Hygrohypnum polare* is shown in Fig. 2, prepared principally from data supplied by Dr. Steere and Mag. Kjeld Holmen, of Copenhagen, to both of whom warm acknowledgment is due. Whether or not the polar basin 'spot' should be added is a question rather for the philosophers of our subject to decide. At least they would not ignore the statisticians' contention that, even if the likelihood of some member of a population crossing a barrier is virtually nil in any one year, in the course of a million years such an event becomes probable, and in ten million years practically certain.

Work reported in this article has been sponsored by the Geophysics Research Directorate, Air Force Cambridge Research Center, under Contract *AF* 19(604)–1144, with the author as Project Director.

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EARTH TILTS IN THE BRITISH ISLES CONNECTED WITH FAR DISTANT EARTHQUAKES

By Prof. R. TOMASCHEK

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THE phenomenon of earthquakes being preceded by characteristic tilting movements of the ground in the same seismic region has been frequently observed[1]. In a recent paper Nishimura[2] has published observations on tilt movements in Japan which can be correlated with very far distant earthquakes. As such movements have also previously been observed in Europe[3] it seemed worth while investigating the possible existence of a world-wide influence of this type. This was readily possible as very sensitive tiltmeters have been in operation[4] in Winsford, Cheshire, since 1950, and records from them could be compared with all the cases given by Nishimura. The comparison shows generally a much steadier behaviour of the Earth's crust in Great Britain than in Japan. This is not merely an apparent effect due to the very stable position of the Winsford tiltmeters at a depth of 143 m. below surface (116 m. below sea-level) so that they are sheltered against the movements of the upper strata the tilts of which are known to be sometimes fairly large. Although many of the Japanese stations are situated at only shallow depths and some of the deeper stations are located in hills, so that they are above sea-level, there are several like Makimina (depth below surface 165 m.; below sea-level 35 m.), Bessi (750 m.; 90 m.), Ikuno (719 m.; 279 m.), Ogoya (300 m.; 90 m.), Hosokura (160 m.; 30 m.), which reach below sea-level. These stations show stronger general drift and tilt movements than are observed at Winsford, indicating that there exists a genuine difference in stability of the ground. It is therefore not surprising to find that most of the tilts connected with distant earthquakes, as observed in Japan at several stations simultaneously, have no characteristic corresponding tilt movements in Winsford, although the epicentric regions may be as different as Tibet, East Indies, Kuriles, Costa Rica. But a definite and extremely strong correspondence occurred on October 22, 1951 (Formosa earthquake).

The upper part of Fig. 1 shows the Winsford record of the north–south pendulum of August 17–19, 1952, containing among others the earthquake in Tibet (91·5° E., 30·5° N.), of magnitude 7 the tilt influence of which in Japan has been discussed by Nishimura. This record indicates that no special tilting was caused at Winsford, and it is an example of the normal behaviour of the tiltmeters showing only the tidal movements. The lower part of Fig. 1 shows the behaviour between 11^h, October 21, 1951, and 9^h, October 24, 1951. A heavy earthquake of magnitude 7 occurred in Formosa (122° E., 24° N.) at about 21^h34 G.M.T. on October 21, 1951. In Japan (distance from the epicentre about 1,800 km.) special ground tilts of about 0·1 second of arc preceded the earthquake for about 20 hr. These tilts are not shown in the Winsford graphs, which are practically smooth (except for the tidal tilts) up to the first arrival of the earthquake movement. But a definite tilt is started by this earthquake, and this fairly steady tilt amounts to about 0·04 second of arc and lasts about 5 hr. after the first arrival of the earthquake. In Japan at the same time at Ikuno, Makinine, Ogoya and Kamigamo a heavy sudden tilt was observed which must have amounted to the order of seconds of arc. This is quite unusual even in the Japanese records and is not shown in any others published. In Winsford a slow, steady but very small tilt continues (partly due to tidal movements) up to about 20^h, October 22. It is interrupted

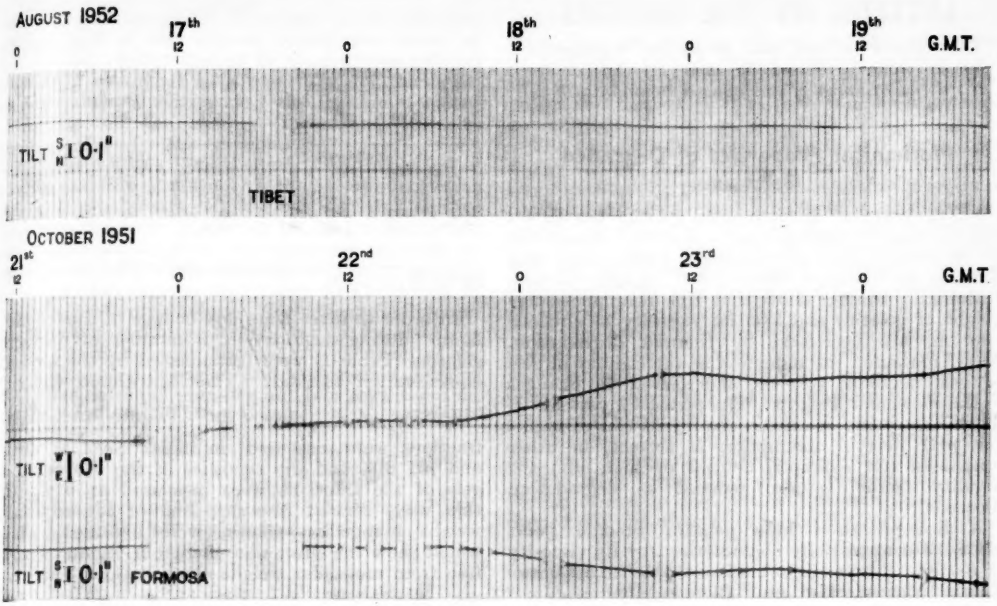

Fig. 1. Tilt records at Winsford, Cheshire

by several earthquakes which have no influence on this movement. Then, with an earthquake at about 20^h, October 22, a strong tilt movement starts which lasts until about 9^h30, October 23 ($13\frac{1}{2}$ hr.), and with an earthquake at this time the tilt movements slow down, but retain a certain drift for the next twenty-four hours. The total tilt within 36 hr. amounts to about 0·2 second of arc. In the Japanese records at Ikuno a progressive tilt very similar to the first short stronger tilt at Winsford can also be observed in one component. The tilt records taken by Dr. Doodson and the late R. H. Corkan at the Tidal Institute at Bidston also show the disturbance very clearly. (I should like to thank Dr. Doodson for showing me the Bidston records.) One has the impression that, initiated by the Formosa earthquake, a large world-wide readjustment of the Earth's crust must have taken place which was fairly rapid and strong in Japan and slower and later in Europe, and lasted here nearly 38 hr., showing even later after-effects.

That strong stresses accumulate in the Earth's crust at this time of the year has also been shown by previous experience[5]. The Winsford records show, furthermore, that a spectacular readjustment took place on October 24, 1950. The title of a lecture by Prof. Benioff[6]: "Evidence for World Strain Readjustment following the Kamtshatka Earthquake of November 4, 1952", seems to indicate the observation of a similar readjustment at very nearly the same date in autumn 1952.

These readjustments seem not to be connected with a considerable change in the distance of the masses from the centre of the Earth. No significant change in the rotational speed of the Earth ($\pm 0{\cdot}1$ thousandth of a second) was connected with the adjustment described in the present note (I thank Sir Harold Spencer Jones for this information).

However, the seasonal recurrence of these readjustments, which indicate the periodic accumulation of stresses in the mantle, shows that a certain connexion with the change of rotational speed of the Earth may exist in the following way. The annual change of rotational speed is due to meteorological factors on the Earth's surface, where the dislocation of masses (air, water, precipitation) takes place. The braking or accelerating effect of the change of moment of inertia has to be transferred to the deeper layers of the Earth. The transition of the Northern hemisphere from summer to winter condition puts, therefore, a heavy stress on these transferring layers. Its release might be observed in the readjustment mentioned above.

Another additive factor can be found in the direct action of the seasonal change of the temperature distribution over the northern hemisphere. It is surprising how deep into the earth these temperature influences penetrate in the form of stresses and strains, as shown by the solar semidiurnal and diurnal variations observed in the course of gravity and tilt measurements in deep mines, where temperature itself is constant in certain cases within a few thousandths of a degree. The change of temperature on a global scale[7] may add up to considerable strains in tectonically coherent areas. [Feb. 23

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Mechanical Properties of Degraded Gelatins

Fractionation[1] of commercial gelatins has shown that the rigidity of gelatin gels is not solely dependent on the distribution of molecular weights but also depends on another factor—the 'rigidity factor'. Scatchard's results[2] show that the mean molecular weight of gelatin, and also its viscosity in aqueous solution, are decreased by thermal degradation. Ferry[3] measured the reduction in the rigidity of gels of these degraded gelatins, and related the changes to the molecular weights. The present investigation shows that while in certain conditions (for example, low *p*H) Ferry's assumption is correct, in other conditions (for example, neutral or high *p*H) the 'rigidity factor' is also reduced as degradation proceeds.

A lime-processed hide gelatin, isoionic point *p*H 5·05 (commercially characterized by its viscosity of 8·7 cp. in aqueous solution at 5·8 per cent w/w gelatin concentration and Bloom jelly strength, 225 *g*), was degraded in 5·8 per cent w/w solution at various temperatures and *p*H's for selected times. The viscosity of the 5·8 per cent solutions at *p*H 6·5 were measured at 40° C. and the rigidities[4] of the corresponding gels were measured at 0° C., after maturing for 18 hr. at 0° C. The results are illustrated in Fig. 1, where each curve represents constant degradation conditions (*p*H, temperature, etc.) and each point represents a given stage in the degradation.

The results may be summarized as follows. (1) At 90° C. and *p*H 5·5, both viscosity and rigidity decreased as the degradation proceeded, the rigidity tending rapidly to zero at the stage when the average molecular weight of the gelatin became too small to permit gel formation, corresponding approximately to a viscosity of 3 cp.; (2) at 60° C. and *p*H 11·2, the rigidity decreased more for a given fall in viscosity than in (1); (3) at 60° C. and *p*H 1·7, the rigidity actually increased slightly as the viscosity decreased, and then fell rapidly as the viscosity approached 3 cp.; (4) at 10° C. and *p*H > 13 in the gel form, the rigidity remained almost constant during the initial stages of degradation and then fell to zero.

These results suggest that for experiments (3) and (4) the 'rigidity factor' is unchanged. Only when a sufficient proportion of very short chains has been formed does the rigidity show a marked decrease. In contrast, the decreased rigidities for the degraded gelatins obtained in (1) and (2) may be explained by a reduction in 'rigidity factor' together with the effect of production of short chains especially in the latter stages.

Table 1

Gelatin	Conditions of degradation: Temp. (° C.)	*p*H	Duration (hr.)	Rigidity* (in 10^3 dynes/cm.^{2})	'Rigidity factor' (% of initial value)	Average log. arithmic viscosity number (% of initial value)
A	Undegraded			112	100	100
B	60	1·7	3	106	110	45
C	60	11·2	3	50·5	60	50
D	90	6·5	7·5	68·5	70	65
E	90	6·5	19	36	50	40
F	10	>13	24	49·5	90	40

* 5·8 per cent gelatin concentration. Measured at 0° C. after maturing for 18 hr. at 0° C.

In order to investigate any change in the 'rigidity factor' during degradation, a number of degraded gelatins (Table 1) were fractionated by the alcohol[5] co-acervation method. The logarithmic viscosity numbers ($\frac{1}{c} \ln \frac{\eta}{\eta_0}$ at $c = 0{\cdot}002$ gm./ml.) of the fractions were measured[6] in molar NaCl at 40° C. and *p*H 6·5, and the rigidities of the 5·8 per cent gels of the fractions were measured at 0° C. In this way, certain fractions free of low-molecular weight non-gelling gelatin were obtained, which would show the effect of a change in 'rigidity factor' free from molecular weight complications.

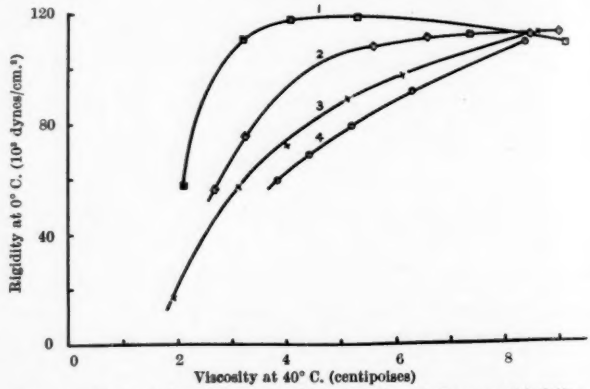

Fig. 1. Thermal degradation of a high-viscosity alkali-processed gelatin: (1) ⊡—⊡—, 60° C., *p*H 1·7; (2) ◇—◇—, 10° C., *p*H > 13°; (3) ×—×—, 90° C., *p*H 5·5; (4) ○—○—, 60° C., *p*H 11·2

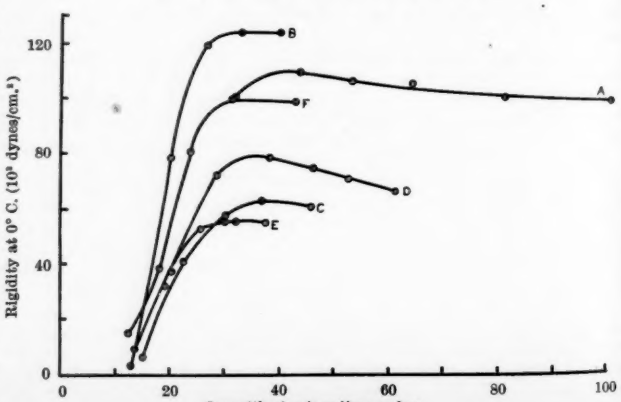

Fig. 2. Rigidity of the fractions of the degraded gelatins

The properties of the fractions of the degraded gelatins and of the original gelatin are shown in Fig. 2. The 'rigidity factors' of the degraded gelatins have been evaluated as a percentage of the undegraded values, by comparing the maximum values of rigidity on the rigidity – logarithmic viscosity number curves for the fractions.

Fig. 2 and Table 1 show clearly that, in neutral or alkaline conditions, not only is the average molecular weight of the gelatin reduced but also the 'rigidity factor' is seriously affected. In acid solutions, in contrast, there is even an apparent increase in 'rigidity factor'. This increase is not considered to be genuine, but to be related to limitations in the fractionation technique. Corrections for fraction homogeneity and degradation during fractionation reduce the discrepancy between the rigidities of the fractions of acid-degraded and undegraded gelatins of equal logarithmic viscosity numbers to zero within experimental error. A full account of this work will be published elsewhere.

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A. G. Ward

British Gelatine and Glue Research Association,
2a Dalmeny Avenue,
London, N.7.
Feb. 25.

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Ultra High-speed Skew-ray Tracing

Several electronic digital computors in Britain and the United States are now being used for tracing skew-rays through optical systems. The speed of calculation varies from machine to machine; but in general the fastest time is probably slightly less than $\frac{1}{2}$ sec. per ray surface, while the slower machines require 1–2 sec. per ray surface.

Some work has been carried out recently using the new experimental Manchester *MK* II Machine (*MEG*) in this connexion. This machine has been programmed to trace single skew-rays through systems at a speed of 0·1 sec. per ray surface. The machine has been described in detail in two publications[1]. As the name implies, the machine has a pulse repetition-frequency of one megacycle, a speed faster by ten times than the Manchester *MK* I, which has already been used for optical work[2,3].

There is at present no magnetic storage for this machine, although provision has been made for this facility. The electronic storage consists of ten cathode-ray tubes operating in the parallel mode. Each tube stores 1,024 binary digits, so that the present full storage capacity is 1,024 ten-digit words. An important feature of this machine is that no attention need be paid to number-ranges, the arithmetical units having been arranged to perform floating-point arithmetic. In optical work this is a valuable feature, for systems of any focal length can be calculated as they stand, a facility which obviates the necessity, using fixed-point machines, for scaling systems up or down to a constant focal length.

All working routines must be stored in the electronic store, although it is possible to use punched tape as an auxiliary store, provided that the original input instructions are not written over. In this case, fresh orders can be read in from tape and the calculation can continue.

The placing of routines 'nose to tail' throughout the electronic store with the necessary alterations due to changes in position is carried out by an input routine due to R. A. Brooker. The method of skew-ray tracing described by me[2] has been strictly adhered to, and provision has been made for the extraction and summation of optical path differences, as it is proposed to use this programme for the evaluation of complete wave-front data.

At a ray-trace speed of 0·1 sec. per surface, it is possible to obtain a very full account of emergent wave-fronts at the exit pupils of systems in a quite reasonable time; and the examination of regions of stationary phase can be conducted in a time comparable with that required for the calculation of a few rays using conventional desk machines.

This work forms part of the programme of the British Scientific Instrument Research Association, carried out under contract to the Ministry of Supply.

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Determination of Elastic Constants of Solids by Ultrasonic Diffraction Methods

Elastic constants of a number of polycrystalline materials such as aluminium, silver, copper, steel, nickel, glass, zinc and brass have been determined using ultrasonic diffraction techniques. The results compare well with the values obtained by other methods.

The experimental arrangement consists of the usual Debye–Sears equipment for observing ultrasonic diffraction patterns. The material in the form of a thin plate, of which the elastic constants are to be determined, is placed in the cell interrupting the ultrasonic radiation from the quartz transducer. Rotation of the plate about the vertical axis causes total internal reflexion, and the transmitted wave disappears, which can be detected by the absence of diffraction pattern.

Since shear waves cannot be transmitted through a liquid, only longitudinal waves incident on the material are considered. When the longitudinal wave is incident in the normal direction, it is transmitted through the plate entirely as a longitudinal wave. As the angle is rotated from 90°, a point comes when there is no transmission of longitudinal waves. This is the first critical angle. As the plate continues to rotate, a second critical angle is obtained at which shear waves in the plate also cease to be transmitted. For points lying beyond this second critical angle there will be no transmission.

Snell's law for angular transmission gives:

$$\frac{\sin\theta}{V_L} = \frac{\sin\theta_L}{V'_L} = \frac{\sin\theta_S}{V'_S}$$

Table 1

Material	Thickness (mm.)	V'_L (m./sec.)	V'_S (m./sec.)	K	μ	ρ	F $\times 10^{11}$ dyne/cm.^{2}	E $\times 10^{11}$ dyne/cm.^{2}
Aluminium	1·32	6,686	3,626	1·84	0·29	2·68	3·52	9·08
Silver	1·66	3,181	1,671	2·1	0·35	10·4	2·90	7·85
Copper	3·26	5,958	2,703	2·2	0·37	8·7	6·34	17·37
Steel	3·09	6,301	3,221	1·96	0·32	7·8	8·1	21·44
Nickel	0·96	4,480	2,394	1·87	0·299	8·9	5·1	13·25
Glass	2·11	5,697	3,221	1·77	0·27	2·58	2·68	6·81
Zinc	1·51	6,686	2,441	2·73	0·42	7·1	4·23	12·01
Brass	1·67	4,480	2,540	1·76	0·26	8·4	5·41	13·67

where θ is angle of incidence of longitudinal waves in the liquid, θ_L is angle of transmission of L waves in solid, θ_S is angle of transmission of S waves in solid, V_L is velocity of L waves in liquid, V'_L is velocity of L waves in solid, and V'_S is velocity of S waves in solid.

At the two critical angles,

$$V'_L = \frac{V_L}{\sin \theta_I} \quad \text{and} \quad V'_S = \frac{V_L}{\sin \theta_{II}}$$

Also $$V'_L = \sqrt{\frac{(1-\mu)E}{\rho(1+\mu)(1-2\mu)}}$$

where ρ is the density, μ is Poisson's ratio and E is Young's modulus, and

$$V'_S = \sqrt{\frac{F}{\rho}} = \sqrt{\frac{2(1+\mu)(1-\mu)}{(1+\mu)(1-2\mu)}}$$

where F is the shear modulus.

Hence, $$K = \frac{V'_L}{V'_S} = \sqrt{\frac{2(1+\mu)(1-\mu)}{(1+\mu)(1-2\mu)}}$$

or $$K^2 = \frac{2(1-\mu)}{1-2\mu}$$

Hence, $$\mu = \frac{K^2-2}{2(K^2-1)}$$

Also, $F = V'^2_S \rho$ and $E = 2(1+\mu)F$.

The results are given in Table 1.

I thank Dr. K. Bannerji for his valuable suggestions and advice during this work.

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High-Pressure Glow-to-Arc Transitions with Tungsten and Copper Cathodes

Further experiments on high-pressure glow-to-arc transitions using the technique described in a previous communication[1] indicate that, with both tungsten and copper cathodes, transitions may be initiated by either low ionization cathode impurities or surface irregularities. It has been found that a stable glow discharge may be operated in oxygen and on either thin or thick oxide layers provided the layers are smooth; but with the same experimental conditions the presence of an irregular oxide layer was found to cause transitions. Transitions were similarly obtained with unoxidized irregular surfaces and surfaces contaminated with irregular semi-conductor layers. In all cases the transitions were observed to take place at the points of irregularity. While it is clear, for example, from the work of Llewellyn Jones[2] and his collaborators, that enhanced emission is obtained from oxide surfaces, our work indicates that a more important factor affecting glow-to-arc transitions appears to be the presence of surface irregularities. An examination of the work of the many previous investigators who conclude that oxides or oxygen produce transitions shows that the transitions which they obtained may well have been produced by the presence of oxide irregularities rather than by the oxide itself. It may be concluded that such irregularities lead to an enhanced field and the consequent rapid formation of a field-emission arc.

It is of interest to consider the formation of arcs from glow discharges when the cathode is free both from surface impurities and irregularities. By careful polishing followed by prolonged cleaning of the cathode in a hydrogen discharge, experiments of this nature are possible. With tungsten electrodes in hydrogen at atmospheric pressure, it was found possible to obtain almost continuous glow-to-arc transitions with a range of electrode diameters from 1/32 in. to 1/8 in. As the diameter is increased, the current at which the transition begins (shown by the rapid fall in the voltage-current characteristic) also increases; but in all cases the overall cathode temperature was found to be $\sim 1{,}800°$ C. at the commencement of the transition. This clearly indicates, in agreement with previous investigations, that the transition is explicable on the basis of the growth of cathode thermionic emission. A small discontinuity in the falling voltage-current characteristics was found to coincide with the sudden constriction of the discharge plasma into the bright red column normally associated with the hydrogen arc. This column transition is no doubt the cause of one of the transitions reported by Suits[3], although we have found no evidence of the further transitions which he reported.

In the case of a clean smooth copper cathode in hydrogen at atmospheric pressure when commencing with a glow discharge, increase in current caused a continuous concentration of the column until a final and sudden contraction took place, producing the bright red column observed with a tungsten cathode. This form of column has been noted previously by Fan[4] and Bruce[5], and its production may well be explained by the shape of the thermal conductivity curve as proposed by Höcker and Finkelnburg[6] and King[7] for the constriction of the carbon arc in air. Despite the formation of this constricted column, the cathode still possessed the normal negative glow and cathode dark space characteristic of a glow discharge. Attempts to increase the current further produced in some experiments a completely molten cathode surface with the production of cathode vapour bursts. Although the cathode surface was molten, the cathodic part of the discharge remained in the glow form. It appears therefore, in contradiction to the work of Plesse[8] and others, that the presence of metal vapour at the cathode does not necessarily

result in the formation of an arc. Further experiments at higher currents with the cathodes cooled to prevent melting produced uncontrolled discontinuous transitions. It may be that in these cases local melting and solidification take place with subsequent transitions at the points of irregularity thus produced. Should it be possible to avoid the formation of such irregularities, it is considered that an arc may well be finally formed on copper and mercury cathodes when the cathode current density is such as to produce field emission as calculated, for example, by Mackeown[9].

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Secondary Expansion of Perlite Concrete and Plaster

Expanded perlite, which is made by rapidly heating small particles of suitable volcanic glass, has recently been used extensively as a lightweight aggregate for gypsum plaster and concrete in the United States, and to a lesser extent in Australia and Europe. The phenomena described below are therefore of some concern to the building industry in those countries.

Unrestrained specimens of perlite plaster show at first a setting expansion followed by a short-term shrinkage, as does normal plaster. At an age of about three weeks, however, a relatively slow secondary expansion at a rate of about 0·1 per cent length increase per annum commences, and under normal atmospheric conditions this expansion continues at a slightly decreasing rate over a long period. The oldest specimens under test in this Division are still expanding at about half the initial rate after 600 days. Perlite concrete shows a similar, though much slower, expansion following an initial shrinkage period of some months[1].

Work which I have done indicates that a slow ion-exchange reaction is the cause of the secondary expansion. Expanded perlite is a glass which contains some exchangeable alkali and alkaline earth ions. In the presence of water, the main process which occurs is that hydrogen ions from the solution are exchanged with sodium ions, and to a lesser extent potassium and calcium ions from the glass. The rate of exchange for a given perlite depends, among other factors, upon the temperature and *p*H of the solution, being greatest at high temperature and low *p*H. Such exchanges taking place in perlite plaster and concrete lead to the formation in the matrix of alkaline hydroxides which may then react with carbon dioxide and moisture from the air, causing the matrix to expand. The quantity which may be exchanged is about 8 m.equiv. per 100 gm. after 60 days and is sufficient to account for the observed expansion.

There is evidence that a further cause of the expansion in perlite plaster is the exchange of calcium ions in the plaster for sodium ions from the glass; the hydrated sodium sulphate which would form in the matrix has a greater volume than the gypsum it replaces. The rates of expansion of perlite plaster and concrete increase with increasing temperature, humidity and proportion of perlite in the mix, and vary considerably for different perlites.

Although some degree of control of expansion may be achieved in the laboratory, it appears that control in job conditions is impracticable. However, preliminary tests on restrained specimens of perlite plaster have shown that all but a small part of the stress caused by expansion is relieved by internal creep. The secondary expansion is therefore not likely to cause failure of perlite plaster provided the rate of expansion of unrestrained specimens at 70° F. and 60 per cent relative humidity is less than 0·1 per cent per annum, and provided suitable construction methods are used. Similar considerations apply to the use of perlite concrete, in which the expansion is usually more than offset by the high initial shrinkage.

A more detailed account of this work is to be published at a later date.

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Condition of Boron in Alpha Iron

The question as to whether boron forms an interstitial or a substitutional solid solution in α-iron is of considerable theoretical and practical interest. Recently measurements have been made, by orthodox methods, of the solubility and diffusivity of boron in both α- and γ-iron[1-3]. These gave the maximum solubility of boron in α-iron as about 0·008 weight per cent at 900° C. The data on the diffusion in α-iron[4] were not precise but indicated an activation energy of 62 kcal. per mole and a D_0 of 10^6 cm.^{2} sec.$^{-1}$. This suggests that boron behaves substitutionally. Some calculations based on estimates of the atomic radius of boron[3] also suggest that boron may be substitutional in α-iron. However, we felt that this evidence was somewhat speculative and not sufficiently conclusive. Obviously, if boron were interstitial, it should be possible to observe an internal friction peak similar to that caused by carbon and nitrogen in α-iron[5,6]. The purpose of the present communication is to describe some exploratory measurements on internal friction which suggest that boron is in interstitial solution in α-iron.

The internal friction technique has been described in detail elsewhere[7]. Essentially a wire specimen forms the torsional suspension of a freely oscillating system. When the logarithmic decrement is plotted against temperature of measurement, the presence of an interstitial solute gives rise to a peak in the curve. The diffusion coefficient is calculated from the frequency of vibration for the temperature at which the peak occurs. The height of the peak is proportional to the amount of interstitial solute in free solution.

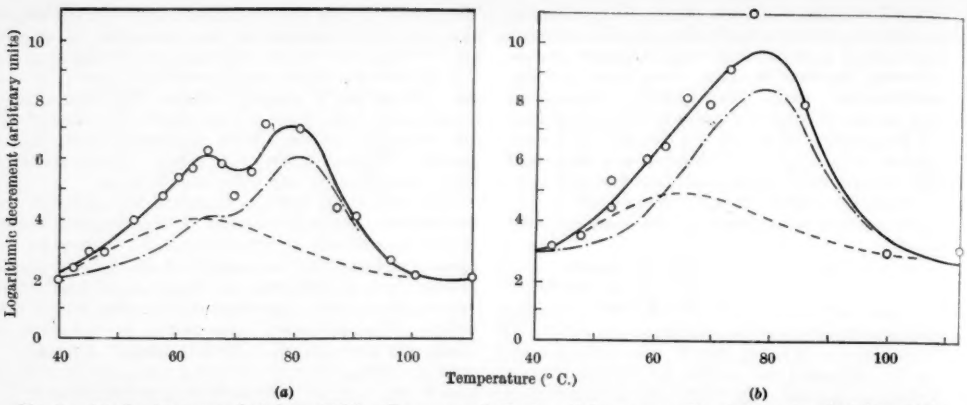

Fig. 1. (*a*) Specimen quenched from 700° C. Frequency of vibration 15·5 per sec.; (*b*) specimen quenched from 900° C. Frequency of vibration 14 per sec. 1 unit of logarithmic decrement is approximately equivalent to 0·001 weight per cent carbon. ———, Experimental curve; – – –, relaxation peak due to 0·002 weight per cent carbon; — . —, difference between observed curve and carbon peak

Internal friction peaks have now been observed in specimens containing boron (Fig. 1). Specimens were produced in the following way. Pure iron wires (0·04 and 0·08 in. diameter) were decarburized and denitrided in flowing wet hydrogen (about seven days at 800° C.). Boron was introduced by annealing the wires, with powdered boron, in an atmosphere of dry hydrogen at 1,000° C. in a closed system. The purest boron that could be obtained contained about 1 per cent carbon. The resulting specimens contained (weight per cent) about 0·05 boron, 0·002 carbon and 0·001 nitrogen (by chemical analysis). Consequently, the only possible controversial point in ascribing the peaks of Fig. 1 to interstitial boron is the fact that carbon was also present in the specimens.

Previous work with wire specimens of similar texture to that used in this investigation gave the proportionality constant between peak height and carbon content in solution. In Fig. 1 one unit of logarithmic decrement is roughly equivalent to 0·001 weight per cent carbon. The curves in Fig. 1 represent specimens quenched from 700° and 900° C.

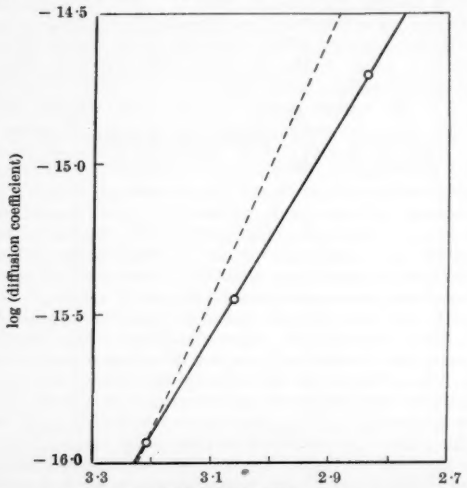

Fig. 2. Variation of diffusion coefficient with temperature. ———, Boron; – – –, carbon

The latter peak height is greater than that for 0·002 weight per cent. It is also at a temperature higher than that corresponding to the peak for carbon, for a frequency of vibration of 14 c./s. Experimental error is greatest at high levels of damping. The curve in Fig. 1*b* has been drawn purposely below the highest observed point because of this. The resultant component curves are then of the form to be expected from theoretical calculation. The specimen quenched from 700° C. gave two resolved peaks corresponding in height to about 0·002 carbon and 0·004 boron (weight per cent). The lower temperature peak corresponds, for the frequency of vibration, to that for carbon[6]. The higher-temperature peak must thus correspond to interstitial boron. A relaxation peak due to substitutional boron would not be observed for such a low concentration of boron, nor at such a low temperature.

Two further points arise from this present exploratory work. Assuming that the proportionality constant between peak height and boron content is the same as that for carbon, the solubility of boron in α-iron can be determined. This solubility is that in equilibrium with precipitated iron boride, presumably Fe_2B. At 900° C. it is 0·005 weight per cent and at 700° C. about 0·004 weight per cent. The assumption is probably untrue; it is more likely that boron strains the iron lattice to a greater extent than does carbon. This would lead to a bigger proportionality constant, and consequently the boron solubility will be less than quoted above.

Secondly, an estimate can be made of the diffusion coefficient, D, of boron in α-iron,

$$D = \frac{a^2 \omega}{36}$$

where a is the lattice parameter of α-iron and ω the angular frequency of vibration.

Measurements carried out at various frequencies are reported in Table 1 and plotted in Fig. 2 in the form $-\log D$ versus $1/T$, where T is the absolute

Table 1

Frequency of oscillation (sec.$^{-1}$)	Temperature of peak (° C.)	Diffusion coefficient × 10^{10} cm.^{2} sec.$^{-1}$
0·8	39	1·18
2·5	54	3·55
14	79	20

temperature at which the internal friction peak occurs.

The corresponding curve for carbon is also plotted in Fig. 2. In view of the results of Fig. 1, however, the evidence for considering boron to constitute an interstitial solid solution is considered satisfactory. The activation energy for diffusion, estimated from Fig. 2, is 15 kcal. per mole, with a D_0 of about 10^{-5} cm.^{2} sec.$^{-1}$. It is not proposed, at this stage, to discuss the differences between the present results and those of previous workers. A more complete report will be given elsewhere.

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Bed-width and Wave-length in Meandering Valleys

In a previous communication[1] it was stated that the alluvium of six winding valleys occupies large channels which meander around the valley bends. Subsequent work in other valleys has provided similar evidence[2], and confirms the view that the valleys were eroded by streams larger than those which now flow in them.

When the width of the alluvium-filled channels is plotted against the size of the drainage basins, it is clear that a relationship exists. A connexion is also observed between the size of catchment and the wave-length of valley meanders (Fig. 1). Equations of best fit have been calculated both for width of channel and for wave-length of meander, with the following results:

$$W = 43\,M^{0.43}$$
$$L = 560\,M^{0.43},$$

where W and L are respectively the minimum width of the filled channel and the wave-length of valley meanders, in feet, and M is the size of catchment in square miles. The close interdependence of the three variables is further illustrated in Fig. 2. The coefficient of correlation between W and M is $+0{\cdot}791 \pm 0{\cdot}067$, while that between L and M is $+0{\cdot}856 \pm 0{\cdot}048$.

The closeness of the connexions is all the more impressive in view of the natural irregularities of development both of the channels and of the valley meanders. The channels are laterally enlarged at bends, and for this reason measurements were taken at the points of inflexion where lateral cutting has been at a minimum and the channel width is least. The effects of distortion of meanders during incision, with or without shift downstream, has been partly offset by taking as a value for wave-length the mean wave-length of a series of bends, some upstream and

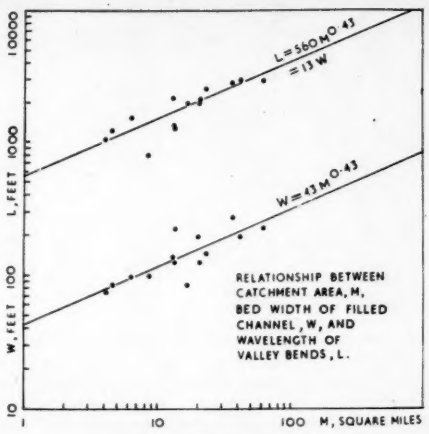

Fig. 1

some downstream of the point at which the channel width was measured.

It is known that the channels of natural meandering streams are shaped at bank-full discharge conditions. It has also been shown that in otherwise constant conditions the dimensions of meanders depend mainly on discharge[3], and that discharge is the principal control of bed-width in natural streams[4]. It follows therefore that, when the valley meanders and large channels now under discussion were being cut, bank-full discharge varied proportionally to catchment area. The circumstance is not surprising, since the catchments dealt with are all small (see Table 1). Even to-day, heavy rainfall or the melting of snow is rapidly followed by a swiftly increasing discharge.

The twelve basins represent a considerable range of hydrographic environments and of relations to former glacial and periglacial conditions. Some of them have been reduced in size, either by river capture or by divide migration, within the Pleistocene. In view of these facts the inferred connexion between size of catchment and amount of former discharge is all the more impressive. It is evident from the contrast in size between the present stream beds and the filled channels, and between the present river meanders and the valley meanders, that all the

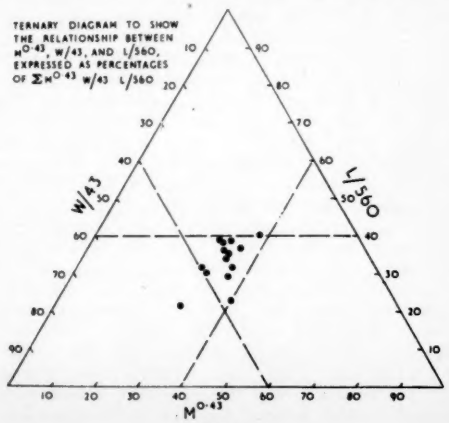

Fig. 2

Table 1. Valleys Measured

River	Size of catchment above measured section of channel (sq. miles)
Thames Basin	
Cherwell	13·3
Coln	13·2
Dikler	4·65
Dorn	13·9
Evenlode	63·2
Glyme	16·85
Leach	21·0
Windrush	6·4
Warwickshire Avon Basin	
Itchen (i)	8·7
Itchen (ii)	23·3
Itchen (iii)	42·3
Herefordshire Wye Basin	
Garren Brook	4·1
Sussex Arun Basin	
Dunsfold Brook	37·0
Kirdford Brook	20·8

streams have suffered a marked reduction of discharge at bank-full stage. The analysis of the results indicates that the reduction has taken place within the limits of the basins as at present defined. River capture is seen to be irrelevant to the question of stream shrinkage. The problem is one of changes in the rate or amount of precipitation, or in both, and possibly also of high surface-discharge from melting snow. This conclusion, already reached on other grounds, is amply supported by the figures analysed here.

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New Zealand Crustal Structure

A seismic refraction profile 170 km. in length has been recorded in the Wellington Province of the North Island by officers of the Geophysics Division, N.Z. Department of Scientific and Industrial Research. The shot point and all recording stations were sited on basement greywacke. A formal solution of the results shows four layers with thicknesses of 0·6, 1·7, 7·2 and 8·8 km. in which the velocities of longitudinal waves are $3{\cdot}5_0$, $5{\cdot}5_2$, $6{\cdot}0_7$ and $6{\cdot}2_2$ km./sec. respectively. The Mohorovičić discontinuity is at a depth of slightly more than 18 km., and the velocity below it is $8{\cdot}0_2$ km./sec. No reverse shot was possible, and gravity data indicate that the discontinuity may be slightly deeper at the northern end. The true velocities could therefore be a little greater than those given by the formal solution. The Mohorovičić discontinuity and possibly the $6{\cdot}0_7/6{\cdot}2_2$ boundary are confirmed by reflexions.

The 3·5 km./sec. velocity is not considered to indicate a separate layer, but to represent the weathered and shattered upper portion of the greywacke with which the 5·5 km./sec. velocity is associated. There is probably no sharp transition between these 'layers'. The earlier conclusion of Bullen[1] from earthquake studies that the 'granitic' layer is thin or absent in New Zealand is not accepted, since the 6·0 km./sec. velocity is that conventionally assigned to this layer. Bullen's results can be reinterpreted to conform with this view. It is uncertain whether the velocity of 6·2 km./sec. is high enough to allow the associated layer to be identified as 'intermediate'.

A detailed account of the observations and discussion of the results will be published later this year as a Memoir of the Geophysics Division of this Department.

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The Nocturnal Heat Balance

It is implicit in the generally accepted theory of the heat balance on clear nights[1–3] that the cooling of the air near the ground is a direct consequence of heat loss to the surface by convection and conduction; ultimately the latter. However, Ramdas and Atmanathan[4] have shown that, in India, under very stable atmospheric conditions, the lowest air temperature is not reached at the surface but at some height above it. This observation is inconsistent with the classical theory. The phenomenon has been observed by workers in other places, notably Brawand and Kohnke[5] in Indiana, and Jenny[6] in Lausanne; but apparently its theoretical implications have not been appreciated. Ramanathan and Ramdas[7], and more recently Rider and Robinson[8], have suggested that under stable conditions certain air layers near the ground may be in radiative rather than conductive equilibrium with their surroundings, the eddy conductivity approaching the molecular value. Sutton[3] and others have stated that the part of the atmosphere mainly concerned in nocturnal radiation exchange is a relatively thin layer near the ground. Now if this layer is considered to be at the same initial temperature as the surface it must be a net radiative loser of heat, and will therefore tend to cool to a temperature below that of the surface; a process more or less retarded by heat gained by convection and conduction from the ground and from the upper air layers. On the basis of this theory, the temperature reached by the surface continues to play an important part in determining that reached by the air near it, but for reasons quite different from those given in the classical theory.

The present investigation confirms the observation of Ramdas[4]. Fig. 1 shows the temperature profile observed over the centre of a thirteen-acre field of entirely bare soil. The temperature of the 'surface' was obtained by taking the mean reading of two spirit-in-glass minimum thermometers resting upon it. It is inconceivable, especially in view of Robinson's observations[9], that the temperature indicated could have been greater than the effective surface temperature under these conditions. The other temperatures were measured with a single type *U* 2361 thermistor, of diameter about 0·01 in., without aspiration or screening. So small an element indicates closely the behaviour of the air temperature. Moreover, the observed profiles could not be adequately explained in terms of errors due to radiation, evaporation or thermal lag, even if these were appreciable. The shape of the profile was confirmed qualitatively by observations with pairs of fully exposed minimum thermometers. A sensitive wind-direction recorder (vane-centre at 14 in. above the surface) remained

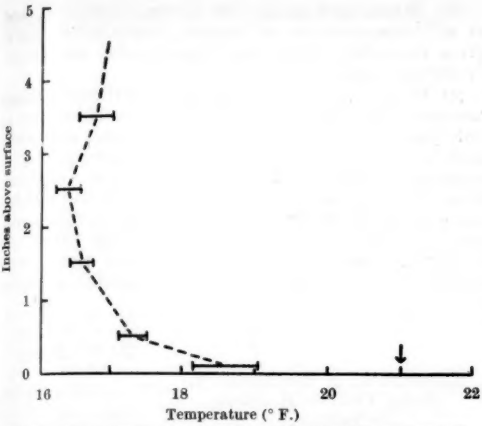

Fig. 1. Mean temperature profile on March 22 for the period 05.42–06.11 G.M.T. (before local sunrise). Sky entirely clear. The mean temperature at 54 in. was 18·4° F. Standard deviations (52 observations) indicated by |—|. Arrow indicates surface temperature

practically motionless throughout the half-hour period of observation.

From these results, and from similar observations made on the two preceding nights, the following conclusions were drawn: (1) the lowest temperature occurred at about 2·5 in. above the surface; (2) the profile of standard deviation of temperature fluctuations about the mean showed a minimum value at about the same level; (3) the negative difference between the surface temperature and that at any height up to 54 in. increased with time, so long as conditions remained stable.

The curious density distribution indicated by this profile has already been noted by Ramanathan and Ramdas[7], and conclusion (2) above supports their view that at the level of the lowest temperature heat exchange must be at a minimum.

Although on less-stable nights the discontinuity in the temperature profile may well disappear, direct radiation loss from the air will presumably continue to be of considerable importance in determining the temperature distribution. This result may be of both theoretical and practical interest, particularly in relation to the frost problem, and a fuller discussion, together with a description of the experimental methods used, will be published elsewhere.

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Accuracy and Reproducibility of Paper Protein Electrophoresis

The analysis of the protein composition of blood serum or plasma by means of zone electrophoresis on filter paper has stimulated interest in clinical laboratories throughout the world. In addition to numerous publications dealing with the applications of the technique in various pathological conditions, critical assessments of its validity and accuracy have appeared[1–4], in which attention is properly directed to the limitations of the method from the point of view of the numerical evaluation of the separated protein fractions. It has seemed desirable to undertake a study of the accuracy and reproducibility of this method of protein analysis, using two of the most commonly employed protein-dyeing techniques.

Protein-free plasma was obtained by heating pooled human plasma in a boiling water-bath for 30 min., and then centrifuging at 3,000 r.p.m. for 2 hr. In this solution, bovine serum albumin (Armour), and bovine globulin (Armour—Fraction V) were dissolved to a concentration of 6 gm. protein per 100 ml. in each case. These stock solutions were diluted with protein-free plasma to give a final concentration of 4 gm. and 2 gm. of albumin and globulin respectively, and then mixed in the proportions shown in Table 1. The mixtures were applied to strips of Whatman No. 1 filter paper in a modification of the method described by Hardwicke[4]. The estimations were carried out in duplicate. 2·5 mm.³ of solution was applied to each of five spots along a line at right-angles to the axis of the paper strips and 6 cm. from one end.

Table 1

Protein conc. (gm./100 ml.)	Albumin – globulin ratio in mixture	Ratios obtained by electrophoresis			
		Naphthalene black 12 *B*		Bromphenol blue	
		Albumin – globulin ratio duplicate		Albumin – globulin ratio duplicate	
2	1	1·1	1·2	1·04	0·82
2	3	2·3	2·2	1·1	2
2	0·33	0·23	0·14	—	—
4	1	0·94	1	1·06	1·3
4	3	2·6	2·7	2·9	3·4
4	0·33	0·38	0·43	0·35	0·43
6	1	1·15	1·25	0·96	0·79
6	3	3·3	3	1·85	1·63
6	0·33	0·51	0·64	0·42	0·57

Electrophoresis was carried out by the method of Grassmann *et al.*[5] using veronal–acetate buffer *p*H 8·6, μ, $\mu = 0{\cdot}05$. The serum-bearing end of the paper was placed at the cathode side of the tank and migration was permitted to continue for 16 hr. at 110 volts.

After drying rapidly in a hot-air oven at 125° C., representative strips were dyed, either for 10 min. in saturated naphthalene black 12*B* in methyl alcohol containing 10 per cent glacial acetic acid; or for 30 min. in 0·1 per cent bromphenol blue in absolute alcohol saturated with mercuric chloride. To avoid uneven dyeing due to air bubbles in the paper strips, it was found necessary to do this in an evacuated desiccator. The strips dyed in naphthalene black 12*B* were washed in 90 per cent methanol – 10 per cent glacial acetic acid until elution of dye had almost ceased, and then in 60 per cent methanol – 6·6 per cent water, 1·2 per cent glacial acetic acid and 0·2 per cent normal hydrochloric acid, until elution was complete. Strips dyed in bromphenol blue were

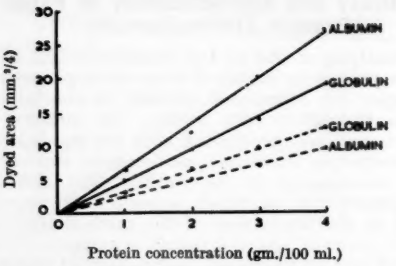

Fig. 1. Relationship between intensity of dyeing and protein concentration. — — — —, bromphenol blue; ———, naphthalene black

washed for 40 min. in four changes of 0·5 per cent acetic acid in water, followed by rinsing in dioxan and ether.

Evaluation of the strips was carried out using the strip densitometer manufactured by Messrs. Bender and Hobein, Munich, the strips being rendered translucent by immersion in a mixture of liquid paraffin and α-bromonaphthalene (6 : 1). Densitometer readings, made at 1-mm. intervals along the strips, were plotted graphically to produce a curve in which each peak corresponded to a protein component. The peaks were drawn as Gaussian curves and the areas beneath the curves measured by planimeter. In order to establish a direct relationship between the areas so measured and the protein concentration on the paper, stepwise increases in concentration of albumin and globulin applied as bands to paper strips were dyed as described, but without preliminary electrophoresis, and evaluated. The results are shown graphically in Fig. 1 and illustrate the rectilinear relationship between dyed area and protein concentration for albumin and globulin for both dye substances used. These findings have been confirmed by D. J. R. Laurence (personal communication). Also shown by Fig. 1 is the difference between the dye-binding capacity of albumin and globulin for both dye substances, together with the considerable reduction in dyeing intensity achieved with bromphenol blue.

The albumin to globulin ratios determined after electrophoresis are shown in Table 1, and from these results the following conclusions may be drawn:

(*a*) Using this particular technique, the concentration of the applied protein solution must be of such an order that the concentration of the minor component, particularly where this is albumin, is adequate to prevent significant loss or reduction by 'tailing', while the concentration of the major component is below that at which understaining or 'packing' is liable to occur[4]. Using bromphenol blue and employing an elution technique, Hardwicke[4] found that the relationship between protein concentration and optical density was lost if the concentration of any one fraction exceeded 1·0 gm. per 100 ml., whereas Martin and Franglen[1], on the basis of a scanning technique and using bromcresol green as dye solution, found that the uptake of dye by unit area of protein varied directly with protein concentration only when that concentration lay between 2 and 3 gm. per 100 ml. In the present experiment a total concentration of 4 gm. per 100 ml. was found to be optimal for accuracy and reproducibility for both the dyes investigated, thus giving a maximum component concentration of 3 gm. per 100 ml. and a minimum component concentration of 1 gm. per 100 ml.

(*b*) When used under the above conditions, and at all concentrations of protein, naphthalene black gives the more correct and reproducible evaluation of protein composition.

(*c*) With either dye, and using the optimum protein concentration, recovery of the protein fractions is only possible to within about ± 5 per cent, and while such a degree of accuracy is not impressive, it is adequate when used as an aid to clinical diagnosis. Such use with pathological sera or plasma will involve an evaluation of the minor globulin components, where concentration must inevitably fall below the optimum necessary for accuracy, and thus small numerical variations must not be regarded as being unduly significant.

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Mode of Action of *iso*Nicotinic Hydrazide

The high specific activity of *iso*nicotinic hydrazide (isoniazid; I) against *Myco. tuberculosis* suggests interference with an essential metabolite.

It is known[1] that hydrazides form stable complexes with copper. The structures (II*a* and II*b*) have been suggested[2,3] for the copper complex of (I), and the anti-tuberculous activity of isoniazid has been attributed[4], without direct experimental evidence, to the ability of the hydrazide structure (—CO—NH—N=) to form such copper (or iron) complexes. We have now obtained the following evidence relevant to this problem:

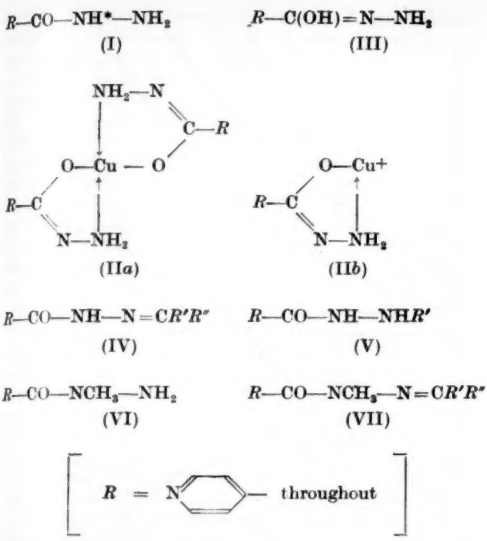
(i) Formation of the copper complex of (I) is accompanied by a marked fall in *p*H, due to the reaction of isoniazid in the tautomeric enolic form, via salt formation of the pseudo-acid (III), to give the complex (II*a* or II*b*).

(ii) Schiff's bases of type (IV) have activity equal to that of isoniazid itself[5], and have been found to form copper complexes of type (II) also.

(iii) Alkyl derivatives of isoniazid of type (V) are also able to form copper complexes of type (II), and have been shown[5] to retain, either wholly or partially, the activity of the parent compound.

(iv) It is therefore clear that the ability to form chelate complexes of type (II) depends on the asterisked hydrogen atom in (I), and that substitution of this hydrogen, for example by methyl, will produce compounds unable to form such complexes.

We have now prepared three such compounds: 1-*iso*nicotinoyl-1-methylhydrazine (VI) and two Schiff's bases of type (VII). These three compounds give, with cupric ion, neither a colour change nor a precipitate. When tested against *Myco. tuberculosis* H37*Rv. in vitro* by the technique previously described[4], side by side with their analogues of structure (IV) and with isoniazid itself, it was found that whereas (I) and (IV) were highly active (this activity is specific for *Myco. tuberculosis*), the corresponding methyl-



substituted compounds (VI and VII) were, by comparison, inactive (Table 1).

Experimental evidence is thus presented that the anti-tuberculous action of isoniazid compounds may be correlated with their ability to form chelate complexes of type (II), and that inability to form such complexes results in disappearance of activity. The action of isoniazid therefore appears to include an essential chelation step.

In view of the fact that the anti-tuberculous action of isoniazid is inhibited by pyridoxal, pyridoxine and pyridoxamine[7], and by α-ketoglutarate and pyruvate[7], it is possible that the metabolic block caused by the isoniazid–metal complex involves interference with transamination, a reaction catalysed by pyridoxal in the presence of heavy metal ions. It is worth noting that the postulated complex formed from pyridoxal, amino-acid and cupric ion[8] bears a marked resemblance to the metal–isoniazid complex (II*a*).

Further work on this problem is in progress, and full details will be published elsewhere. We wish to thank the National Health and Medical Research Council and the Rockefeller Foundation for partial financial support.

Table 1. Tuberculostatic Activity in Serum-Synthetic Medium

Compound	Chelation with copper at *p*H 7	Highest dilution completely inhibiting growth of *Myco. tuberculosis* H37*Rv*. after 14 days at 37° C.
Isoniazid (I)	+	*M*/2,400,000
1-*iso*Nicotinoyl-1-methylhydrazine (VI)	–	*M*/250
1-*iso*Nicotinoyl-2-(*p*-nitrobenzylidene)hydrazine (IV; R' = H; R'' = 4-$NO_2C_6H_4$-)	+	*M*/1,200,000
1-*iso*Nicotinoyl-1-methyl-2-(*p*-nitrobenzylidene)hydrazine (VII; R' = H; R'' = 4-$NO_2C_6H_4$-)	–	< *M*/32,000*
1-*iso*Nicotinoyl-2-(3′ : 4′-dimethoxybenzylidene)hydrazine (IV; R' = H; R'' = 3 : 4(CH_3O)$_2C_6H_3$-)	+	*M*/4,800,000
1-*iso*Nicotinoyl-1-methyl-2-(3′ : 4′-dimethoxybenzylidene)hydrazine (VII; R' = H; R'' = 3 : 4(CH_3O)$_2C_6H_3$-)	–	*M*/2,000

* Strongest solution obtainable

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Liberation of Amino-Acids by Oat Seedlings

In a recent communication[1], the excretion of amino-acids by roots in relation to desiccation was discussed, and an indication given that plants grown under sterile conditions excreted ninhydrin-positive substances from their roots. In view of the importance of such root exudates in rhizosphere microbiology, the following preliminary report on the excretion of amino-acids by oat seedlings grown under sterile conditions may be of interest.

The method of obtaining material exuded by oat seedlings was by means of a perfusing system (a modification of the Lees–Quastel perfusion apparatus[2] was utilized). Surface-sterilized oat grains were placed on the surface of a column of sterile sand which could be irrigated with a sterile inorganic mineral nutrient solution (the total volume of perfusate being initially 150 ml.). The perfusion system was a closed one, sterile air being pumped into the system to effect perfusion of the sand column. Regular tests on the perfusate were made to check the sterility of this liquid. Sterility tests were effected by drawing off 1-ml. samples of the perfusate at four-day intervals, incorporating such samples with cooled molten Czapek–Dox agar (at *p*H 7), which was then dispensed into Petri dishes. The plates, thus prepared, were incubated and observed daily for the development of micro-organisms, the development of which would indicate a loss of sterility by the perfusing system.

Rapid germination of the oat grain ensured the formation of a dense root mass in the sand column. Perfusion was effected for three half-hour periods daily until the seedlings were twenty-eight days old. The perfusate was then collected and concentrated *in vacuo*, the residue being taken up in 5 ml. alcohol.

This resulting solution was utilized (*a*) for colorimetric tests for the presence of amino-acids, and (*b*) for the chromatographic analysis of the amino-acids present.

A positive colorimetric reaction for amino-acids was given, and the chromatographic analysis demonstrated the presence of several amino-acids in the exudate preparation, among which cystine, glycine, alanine and aspartic acid have been identified.

Tests on concentrated perfusates from sterile sand columns in which no oats were grown showed no amino-acids present.

With the results given here, it is not possible to ascertain the relative roles of the grain and the roots in the excretion of amino-acids into the growing-medium; investigations are in progress to attempt to elucidate this. The work is being carried out as part of a study on the metabolism of soil micro-fungi with particular reference to forms inhabiting the rhizosphere and root surface.

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Action of Ribonuclease on Two Solid Tumours *in vivo*

The effects of ribonuclease on ascites tumours have been described recently[1]. The present communication gives preliminary results obtained on two solid tumours, namely, the spontaneous mammary tumour in *C3H* or C^+ mice and the Crocker 180 sarcoma in C^+ mice.

The enzyme used in these experiments was the commercial product produced by Armour from beef pancreas (the preparations used were sterilized by Seitz filtration). It has been mentioned elsewhere[2] that this enzyme preparation differed in some respects from that described in the literature[3,4] and from other commercial sources. It may suffice to state here that the Armour product as used contained about 25–30 per cent of fully active ribonuclease, the remaining 70–75 per cent being inactive ribonuclease and material of low molecular weight. The results obtained with the ascites tumours gave an indication that the inactive portion of the enzyme preparation could, to some extent, inhibit the action of the active one. It is suggested, therefore, that the results obtained on solid tumours represent thus a minimum effect with the concentrations used.

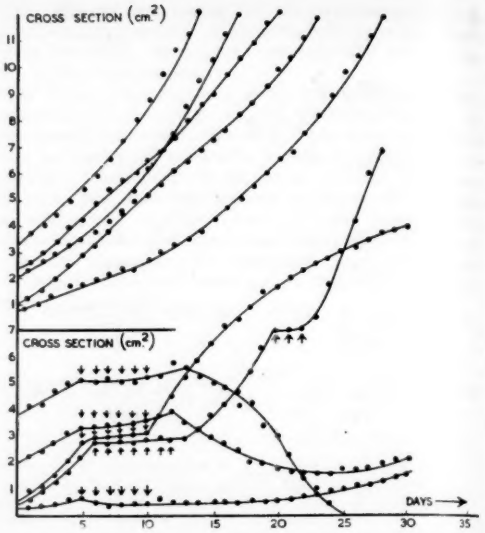

Fig. 2. Sarcoma 180. Treated animals received daily injections of: ↓ 25 mgm. ribonuclease, or † 12 mgm. ribonuclease, dissolved in 0·5 ml. saline. Controls were injected with equal volumes of saline

Fig. 1 shows the growth-curves of untreated and treated spontaneous mammary tumours in *C3H* or C^+ mice. The size of the tumours was estimated either directly on the animal by measuring two perpendicular diameters and using their product as an expression of the size of their cross-section, or by determining with a planimeter the area of the tumours on photographs taken under standard conditions. This estimation was carried out daily for a period of seven to fifteen days prior to the commencement of the treatment, and this initial curve can serve as an additive control of the effects achieved. Controls were selected from animals showing approximately the same growth-rate as the treated ones, and while the enzyme preparation was administered to the latter by intraperitoneal or subcutaneous injections (*I* and *S* respectively on the graph) the former were given injections of saline solutions. This would exclude the possibility of injection effects in the treated series.

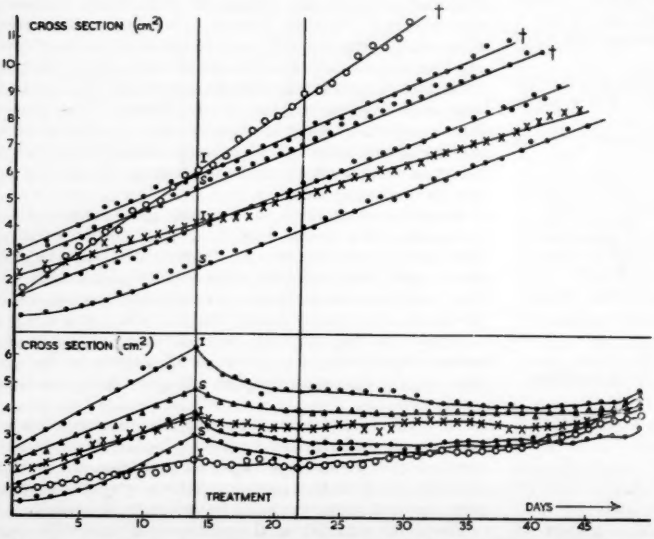

Fig. 1. Spontaneous mammary carcinoma. Treated animals received daily injections of 25 mgm. of ribonuclease dissolved in 0·5 ml. saline. Controls received daily injections of saline (0·5 ml.)

The mammary tumours used are known to regress spontaneously only very rarely[5], and although not always giving the same results in certain cases[6], they are certainly among the most resistant tumours to any drug used. In consequence, the effect of the treatment by ribonuclease as shown in Fig. 1 appears to be really significant: in a number of treated animals, regression occurs, and in

all of them the growth of the tumour was arrested while the treatment lasted. The regression in size of the tumours is a transient one with the doses used; but it lasts for some time after the treatment has ceased. It should be emphasized that the doses used are probably not optimal ones. In fact, it was impossible to establish any toxicity-levels of ribonuclease at doses up to 200 mgm./mouse. The only side-effect of the enzyme preparation seems to be loss of hair. The hair starts falling out a few weeks after the beginning of the injections, but grows again when tumour-growth recommences; otherwise, the animals continue to take their food normally.

In Fig. 2, the results obtained on animals with sarcoma 180 (Crocker) are given. In this case, ribonuclease was administered by intraperitoneal injections only. The animals for this experiment were selected from the best of a group with implantations. In each of the animals the growth of the tumour was inhibited during treatment but continued after the cessation of the injections. In some animals a regression was noticed, and in one animal the tumour disappeared. However, none of the control animals showed any regression in tumour growth. In treated animals in which regression was observed, this was usually accompanied by necrosis of the tumour, not observed in the control series.

These preliminary results clearly reveal that ribonuclease can influence the growth of certain solid tumours, and they also indicate that it should be possible to interfere with the nucleic acid metabolism of tumour cells by enzymic means, possibly similar to the action described by Haddow *et al.*[7] for xanthine oxidase from cows' milk, another nucleolytic enzyme.

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Variations in the Direction of Venous Blood-flow in the Mammary Region of the Sheep and Goat

It is commonly held that the udder of the cow, sheep and goat is drained by three main veins on each side[1]. These are: (*a*) the external pudic, running with the main artery through the inguinal canal; (*b*) the perineal, running up behind the udder to the perineum; (*c*) the caudal superficial epigastric (subcutaneous abdominal or 'milk vein'), running forward along the abdomen (Fig. 1). We have made

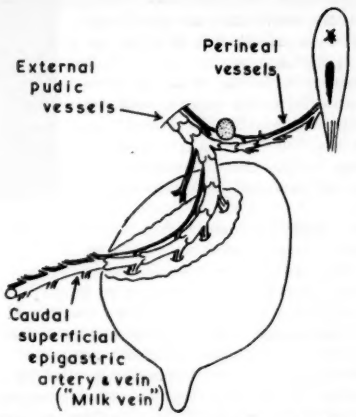

Fig. 1. Main vessels of the udder of the sheep and goat, indicating the position of the venous valves (left lateral aspect). Arteries black; veins white

observations which are at variance with this generally accepted scheme.

At the end of an experiment involving the measurement of blood-flow through the udder of a lactating sheep, it was of great interest to find that the intramammary portion of the 'milk vein' contained valves directed caudally, although, during the experiment, blood had been flowing freely in a cranial direction through the same vein. In view of the fact that the 'milk vein', cranial to the udder, is always used as the source of mammary venous blood in milk secretion studies, we have examined a number of animals for the presence of valves and determined the direction of flow in anæsthetized and conscious animals by visual inspection, after intravenous injections of coloured solutions (milk or Evans blue) or by fluoroscopic examination after injections of iodoxyl.

In all animals examined anatomically (ten goats and ten sheep), nulliparous and multiparous, valves have been found in all three main veins in approximately the positions indicated in Fig. 1. In virgin animals all the valves were quite competent; but in pregnant or lactating animals, the valves in the 'milk vein' were often completely incompetent and allowed fluids to pass in either direction or broke down under slight fluid pressure. The angle of junction of the tributaries with the veins agreed with the orientation of the valves as regards the expected direction of flow (Fig. 1).

In some of the animals examined anatomically (five sheep and two goats) the direction of flow in the mammary veins was determined previously under anæsthesia. It was found that in the virgin sheep and goat the flow was towards the external pudic in the direction of the valves in the 'milk vein' and in the perineal vein, in both the supine and prone (standing, supported in a frame) positions. In pregnant and lactating animals the flows were also towards the external pudic in the supine position. In the prone position, however, the main perineal flow remained craniad, towards the udder (except in one animal where it was craniad near the udder and caudad near the perineum); but the flow in the 'milk vein' was reversed and carried blood cranially, away from the udder against the valves. In one lactating sheep (first lamb), in the prone position, the flow in the back half of the intramammary part of

the 'milk vein' was caudad (with the valves) and that in the front half craniad. However, in a multiparous pregnant sheep and in a multiparous lactating goat the flow was craniad in the prone position along the entire vein. No blood was leaving via the external pudic vein and the 'milk vein' contained a mixture of perineal and mammary blood.

These findings have been confirmed in four conscious goats in which the 'milk vein' on one side had been exteriorized as a vein loop just in front of the udder. The animals were examined standing quietly in a stand without restraint (generally eating). In the two multiparous animals examined, the 'milk vein' flow was craniad towards the end of one lactation, when completely dry and when pregnant again. However, in two virgin kids, the flow in the umbilical region was craniad, but farther back near the udder it was quite clearly caudad.

The occurrence of valves in the perineal vein of the cow has been previously reported by Becker[2], and Becker and Arnold[3] have also described them in the other veins of the cow (which we confirm), but the actual directions of flow were not determined. However, Gracev[4] described valves in the perineal vein of goats and found the flow to be towards the udder (craniad) in eighteen of twenty-one animals, presumably supine and anæsthetized.

Our preliminary findings would indicate that the direction of flow in the veins draining the area of skin in which the mammary glands develop in the ruminant is determined by the state and history of the animal. In the virgin the inguinal and perineal areas are drained by the caudal superficial epigastric and perineal veins into the external pudic. We suggest that the great increase in mammary blood-flow consequent on pregnancy and lactation is associated with a physiological dilatation of the veins, and consequent valvular incompetence, so that the flow in the 'milk vein' is apparently reversed in the standing position and may carry mammary and perineal venous blood. Whether the flow in the perineal and external pudic veins is ever reversed in any circumstances, and whether these results apply to the dairy and beef cow, remain to be determined.

J. L. Linzell
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Agricultural Research Council,
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Babraham, Cambs.
March 7.

[1] Espe, D., "Secretion of Milk" (3rd edit., Ames, Iowa, 1946). Turner, C. W., "The Mammary Gland", vol. 1 (Columbia, Missouri, 1952).
[2] Becker, R. B., *J. Dairy Sci.*, **20**, 408 (1937).
[3] Becker, R. B., and Arnold, D., quoted by Turner (ref. 1).
Gracev, I. I., *J. Gen. Biol., Moscow*, **10**, 401 (1949).

Origin of Blood Platelets

The conclusion of J. H. Wright[1] that blood platelets are detached portions of the cytoplasm of megakaryocytes has been supported by much circumstantial evidence, and is generally accepted[2], although unequivocal direct evidence is lacking.

In the course of other experiments[3], an antiserum against guinea pig platelets was prepared in rabbits,

(1) Megakaryocyte stained by conjugated anti-platelet globulins (× 180); (2) same field as (1), stained with hæmatoxylin and eosin (× 180); (3) megakaryocyte (arrow) treated with conjugated normal globulins (× 180)

which was rendered specific for platelets by repeated absorption with other cells and tissues, and which upon injection into guinea pigs caused complete disappearance of platelets from the blood without affecting the numbers of other cells. The globulin fraction of this serum was conjugated with fluorescein isocyanate by the method of Coons and Kaplan[4], absorbed well with liver powder and used for staining impression smears of guinea pig spleen and bone marrow, which had been fixed by immersion in 95 per cent ethanol at 37° for 15 min. After thorough washing in saline buffered at *p*H 7·5, the slides were mounted in glycerol and were examined by ultra-violet illumination at 3650 A. (using an 80-W. 'Osira' lamp and a quartz cone dark-ground illuminator).

Apart from polymorphonuclear leucocytes, which had a bluish-grey fluorescence, the only cells in the smears which fluoresced were megakaryocytes, and these had the apple-green colour of the fluorescein-coupled proteins. In smears treated with normal rabbit globulin conjugated with fluorescein, the polymorphonuclear leucocytes appeared the same, but megakaryocytes were unstained (Figs. 1–3).

Megakaryocytes must therefore share with platelets some characteristic unique antigenic structure, and this fact may be regarded as direct evidence of their relationship.

I wish to thank Mr. M. R. Young for carrying out the optical side of this work and for preparing the photographs.

J. H. Humphrey

National Institute for Medical Research,
The Ridgeway, Mill Hill,
London, N.W.7.
March 8.

[1] Wright, J. H., *J. Morphol.*, **21**, 263 (1910).
[2] Tocantins, L. M., *Medicine*, **17**, 175 (1938).
[3] Humphrey, J. H., and Jaques, R., *J. Physiol.*, **128**, 9 (1955).
[4] Coons, A. H., and Kaplan, M. H., *J. Exp. Med.*, **91**, 1 (1950).

Microfilaræmia in Rock Rabbits

During the course of studies on transmission of Bancroftial filariasis on Ukara Island in Tanganyika, domestic and wild animals were examined for microfilarial infections. Among those infected were rock rabbits, *Heterohyrax syriacus diesneri* Brauer. Of 28 specimens of mixed sexes, 57 per cent were infected. Records of the number of microfilariæ in thin blood films, prepared by a standardized technique, are compared with body-lengths of the individual hyrax in Table 1. The results may be of interest because they show a general positive correla-

Table 1

Males	Body length (mm.)	325	328	358	364	374	379	416	418
	No. microfilariae	0	0	0	0	0	0	1	0
	Body length (mm.)	448	458	462	465	468	475	493	
	No. microfilariae	129	66	7	7	48	60	98	
Females	Body length (mm.)	368	410	425	455	457	458	465	465
	No. microfilariae	0	0	0	0	3	3	5	1
	Body length (mm.)	466	471	473	475	491			
	No. microfilariae	26	38	4	54	0			

tion between size of host and intensity of a microfilarial infection in a species of wild mammal taken directly from the field.

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Jan. 22.

Correlation between Cloud Shade and Shedding in Cotton

The cotton plant is well known to shed some of its fruiting-points following periods of cloudy weather, and such shade-induced losses are often in excess of the natural shedding normally associated with healthy cotton plants growing in a cloudless environment. Dunlap[1] was able definitely to show that phases of excess shedding followed two to eight days after a particular cloud event. Confirmation of Dunlap's work was recently published[2], and it was further demonstrated graphically that a series of cloud changes was followed by corresponding variations in the number of fruit-points lost daily from plants at Tokar in the Anglo-Egyptian Sudan. For some of the varieties tested, however, prolonged periods of cloudy weather were not associated with sustained heavy shedding.

The varieties examined at Tokar show a lag of two to four days between cloud event and the associated shedding. A direct comparison between cloudiness, as measured on the octant scale, and numbers of fruit-points shed is possible by correlating shedding with cloud events which occurred two to four days earlier. For four of the six varieties in Table 1, it was possible to demonstrate (method *A*) a direct correlation between the fruit-points lost and the highest daily cloud amount as assessed at 0600 and 1200 hr. G.M.T. Varieties *BLR* 14/25 and *X* 1730*A* failed to show a significant correlation when tested by this method; both these varieties were unable to sustain shedding at an increased rate during two or three days of continued cloudy weather. For these varieties an arbitrary method (*B*) was used in which shedding was compared with the first only of a series of cloud changes, in excess of six-eighths amount. By this method *BLR* 14/25 showed a high degree of correlation, whereas *X* 1730*A* just failed to reach significance level of correlation between shedding and cloud amount at probability $P = 0{\cdot}05$.

The varieties tested by method *B* might be considered as having become adapted to cloud-shade following the first of a series of cloud events over six-eighths amount. These varieties at Tokar developed slowly, and during December at least carried only a small boll load. The more sensitive varieties listed against method *A*, which were able to respond to most of the cloud events, had developed more rapidly and carried a heavier boll load. It is possible that this inability of some varieties to respond to all cloud events may provide evidence in favour of the usually postulated mechanism of temporary carbohydrate shortage within the plant as being the fundamental cause of shedding during periods of cloudy weather. In this way it is possible that the plants nearest maturity and with the heaviest boll loads were the most likely to be unable to tolerate temporary or continued internal shortages of available photosynthesates.

Table 1. Correlation Coefficients linking Shedding of Fruiting-Points with Maximum Daily Cloud Amounts

Variety	Method	Period examined	Calculated value of r	r value at $P=0{\cdot}05$	Shedding advancement
Coker-Wilds 11	*A*	Dec. 4–31	0·514	0·381	2 days
BAR 12/9	*A*	Dec. 4–31	0·446	0·349	3 ,,
NT 96/40	*A*	Dec. 19–30	0·735	0·576	4 ,,
Domains-Sakel	*A*	Dec. 14–28	0·587	0·532	3 ,,
BLR 14/25	*B*	Dec. 4–Jan. 31	0·571	0·325	3 ,,
X 1730*A*	*B*	,,	0·324	0·325	3 ,,

I am grateful to the Chief of Research Division, Ministry of Agriculture and Forests, for permission to publish this communication.

Alan Goodman

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Gezira Research Farm,
Ministry of Agriculture and Forests,
Sudan Government.
Jan. 19.

[1] Dunlap, A. A., Tex. Agric. Exp. Stat. Bull. No. 677 (1945).
[2] Goodman, A., *Emp. Cott. Grow. Rev.*, 32, (1), 24 (1955).

Protoplasts in 'Mature' Wood Elements

In a recent communication[1], Mia reports the presence of nuclei and cytoplasm in mature vessel elements and fibre tracheids, and states that his findings are contrary to the observations of Esau and of Eames and MacDaniels in their text-books of plant anatomy. Mia's interpretations of the statements are very loose. He quotes Esau[2]: "in the mature state, tracheids and vessel members . . . with lignified walls" are "devoid of protoplasts", and "after the secondary wall is fully formed and lignified, the swollen parts of the primary wall break down and finally the protoplasts break down and disappear". Esau's statements certainly cover the possible existence of a protoplast in a vessel element after the primary wall of the perforation plate breaks down. She does not state that disappearance of pore wall and protoplast coincide.

Mia's sketch of a vessel element is in itself proof that the protoplast is disintegrating: it is a shrunken mass restricted to a small area on one side of the cell. This is the characteristic appearance of the dying protoplast in such cells, as frequently seen in maturing xylem.

Mia does not quote directly from Eames and MacDaniels's text-book[3], but indirectly from Shah[4], with the words "the disappearance of the protoplasts usually synchronizes with the formation of perforation plates". This is not a correct quotation. Eames

and MacDaniels state (ref. 3, p. 101) that when the "secondary wall is partly, perhaps even fully formed, the perforation of the end wall and loss of the protoplast begin". They make no statement as to which process is completed first, but state only that "as the cytoplasm gradually goes to pieces, it (the perforation plate) also disintegrates". Probably no critical study of the very last stages of vessel-element maturation has been made; but the protoplast must control the dissolution of the plate and therefore persist at least until the completion of the perforation. Mia has apparently described the last stage in the maturation of the vessel segment. He remarks that "the protoplasts disappear after the deposition of the secondary thickening matter"; Eames and MacDaniels stated this in 1925.

Mia also claims and figures the presence, in one species of *Corchorus*, of abundant fibre tracheids with protoplasts. His figures of these cells do not illustrate fibre tracheids but probably substitute fibres, because the pits shown are simple, as in these fibres, not bordered, as in fibre tracheids. Substitute fibres are characteristic of woody herbs, such as *Corchorus*, and fibre tracheids are usually absent.

Further, Mia finds the protoplast-containing fibre tracheids in only some varieties of jute, and vessel elements with cytoplasm only rarely. It is evident that he is dealing either with immature cells or abnormal tissues.

Shah[4], in also claiming the "rather remarkable" presence of protoplasts in "mature" wood cells of the tendrils of *Vitis*, is likewise apparently misinterpreting maturity of the cells in question. He describes vessel elements and fibre tracheids as mature because their walls are lignified. This is not proof of maturity, for it is well known that lignification of the cell wall characteristically begins long before the cell is mature. The cells figured came from immature tendril tips where there were doubtless only immature cells.

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L. H. MacDaniels

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Ithaca, New York.
March 12.

[1] Mia, A. J., *Nature*, **175**, 177 (1955).
[2] Esau, K., "Plant Anatomy" (New York, 1953).
[3] Eames, A. J., and MacDaniels, L. H., "An Introduction to Plant Anatomy" (2nd edit., New York, 1947).
[4] Shah, J. J *Curr. Sci.*, **23**, 65 (1954).

Random Association of Points on a Lattice

For a lattice of rectangular array of points each of which takes any one of k characters or colours with probabilities $p_1, p_2 \ldots p_k$, Moran[1] and Iyer[2] have considered the distributions for the number of joins between adjacent points of the same or different characters. The distributions for joins between points which are adjacent or not are more complicated and therefore do not seem to have been considered. The present communication gives the first and the second moments and also the nature of the higher cumulants for the distributions of the number of joins between adjacent and alternate points including diagonals of 2×2, 2×3, 3×2 and 3×3 sub-lattices, no join being counted more than once, for two- and three-dimensional lattices.

(1) *Joins between points of the same character.*

(*a*) $m \times n$ *: two-dimensional lattice.*

$$\mu_1' = (12b - 15a + 18)p_r^2.$$
$$\mu_2 = (12b - 15a + 18)p_r^2 + 8(69b - 145a + 299)p_r^3 - (564b - 1175a + 2410)p_r^4.$$

(*b*) $l \times m \times n$ *: three-dimensional lattice.*

$$\mu'_1 = (62e - 75d + 90c - 108)p_r^2$$
$$\mu_2 = (62e - 75d + 90c - 108)p_r^2 + 4(3813e - 7700d + 15490c - 31088)p_r^3 - (15314e - 30875d + 62050c - 124460)p_r^4$$

(2) *Total number of joins between points of different colours.*

(*a*) $m \times n$ *: two-dimensional lattice.*

$$\mu'_1 = 2(12b - 15a + 18)\Sigma p_r p_s.$$
$$\mu_2 = 2(288b - 595a + 1214)\Sigma p_r p_s - 2(1428b - 2960a + 6052)\Sigma p_r p_s p_t - 4(564b - 1175a + 2410)\Sigma p_r^2 p_s^2 + 8(564b - 1175a + 2410)\Sigma p_r p_s p_t p_u$$

(*b*) $l \times m \times n$ *: three-dimensional lattice.*

$$\mu'_1 = 2(62e - 75d + 90c - 108)\Sigma p_r p_s$$
$$\mu_2 = 2(7688e - 15475d + 31070c - 62284)\Sigma p_r p_s - 2(38378e - 77300d + 155260c - 311312)\Sigma p_r p_s p_t - 4(15314e - 30875d + 62050c - 124460)\Sigma p_r^2 p_s^2 + 8(15314e - 30875d + 62050c - 124460)\Sigma p_r p_s p_t p_u$$

In the above expressions, $a = m + n$, $b = mn$, $c = l + m + n$, $d = lm + mn + nl$ and $e = lmn$. The summations extend to values of r, s, t and u such that $1 \leqslant r < s < t < u \leqslant k$.

The higher cumulants are linear functions of a and b or c, d and e, and therefore as l, m and n tend to infinity all these distributions tend to the normal form so long as the p's are finite. If some of the p's are very small, the distribution for joins between points of the same kind tends to the Poisson form.

Similar results have also been obtained for the distributions between points separated by h or less points, h taking values 3, 4 etc. When joins between any two points of the lattice are considered, μ'_1 and μ_2 for the total number of joins between points of different colours reduce to the following expressions:

$m \times n$ *lattice.*

$$\mu'_1 = b(b-1)\Sigma p_r p_s$$
$$\mu_2 = b(b-1)\{(b-1)\Sigma p_r p_s - (5b-6)\Sigma p_r p_s p_t - 2(2b-3)(\Sigma p_r^2 p_s^2 - 2\Sigma p_r p_s p_t p_u)\}$$

For the three-dimensional lattice also the above expressions give μ'_1 and μ_2 provided we replace b by e. The rth cumulant will be of degree $(r + 1)$ in b or c. Hence the limiting form of this distribution for large l, m and n is normal. It may be further added that when the points of the lattice take quantitative values, say, $\theta_1, \theta_2, \ldots \theta_k$ with probabilities $p_1, p_2, \ldots p_k$, respectively, the nature of the distributions obtained by considering the sums of the moduli or squares of the differences between observations situated on a sub-lattice similar to those discussed in this communication have also been worked out. These distributions also tend to the normal form as l, m and n tend to infinity.

Full details of these investigations will be published shortly elsewhere.

P. V. Krishna Iyer

Defence Science Laboratory,
New Delhi.
Jan. 25.

[1] Moran, P. A., *Nature*, **158**, 521 (1946).
[2] Krishna Iyer, P. V., *Nature*, **160**, 714 (1947); **162**, 333 (1948); *Biometrika*, **36**, 135 (1949).

FORTHCOMING EVENTS

Monday, July 4

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Theatre of the Science Museum, South Kensington, London, S.W.7), at 5.30 p.m.—Dr. L. G. A. Sims : "The History of the Determination of the Ohm".

Monday, July 4—Wednesday, July 6

SOCIETY FOR APPLIED BACTERIOLOGY (at Cambridge)—Summer Conference and Annual Meeting.

Monday, July 4—Tuesday, July 5

Symposium on "Food Microbiology and Public Health".

Monday, July 4—Saturday, July 9

MUSEUMS ASSOCIATION (at the Barber Institute of Fine Arts, The University, Birmingham 15)—Annual Conference.

Tuesday, July 5—Wednesday, July 6

PHYSICAL SOCIETY (in the Lecture Theatre of the George Holt Physics Laboratory, The University, Liverpool)—Summer Meeting—"High Energy Nuclear Physics".

Tuesday, July 5—Thursday, July 7

INSTITUTE OF PHYSICS, ELECTRON MICROSCOPY GROUP (in the Chemistry Department, The University, Glasgow)—Annual Conference

Wednesday, July 6

ROYAL METEOROLOGICAL SOCIETY (at the College of Aeronautics, Cranfield, Bedfordshire)—Summer Meeting.

Saturday, July 9—Wednesday, July 13

EUROPEAN ASSOCIATION FOR ANIMAL PRODUCTION (at the University, Reading)—Fifth Study Meeting—"Animal Production from Grass".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned :

SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in metallurgy, or in physics or chemistry, if with metallurgical experience, and at least two years works or laboratory experience, preferably in the non-ferrous industry) at the Royal Mint, for duties which include the supervision of production from the metallurgical point of view ; investigation of problems of material and manufacture ; examination and assay of coins suspected to be counterfeit ; and research into the properties of alloys to decide their suitability for coinage—The Secretary, Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S.4479/33 (July 7).

ASSISTANT LECTURER IN PHYSICS—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (July 9).

LECTURER or ASSISTANT LECTURER IN BOTANY—The Registrar, The University, Hull (July 9).

LECTURER (with a good degree in zoology, and preferably with some research, industrial or other relevant experience) IN BIOLOGY—The Principal, Acton Technical College, High Street, Acton, London, W.3 (July 9).

RESEARCH FELLOW (physicist or engineer with experience of high-vacuum and high-voltage apparatus) IN THE NUCLEAR PARTICLE LABORATORY, to investigate the production of short duration, high intensity pulses of electrons with energies up to 2 MeV—The Registrar, Queen Mary College, Mile End Road, London, E.1 (July 15).

CHEMICAL ENGINEER (with a first- or second-class honours degree, plus a professional qualification in chemical engineering, and experience in the chemical industry), to carry out development work to the pilot plant stage, for the Chemical Division of the Rubber Research Institute of Malaya, Kuala Lumpur, and at the R.R.I. Experiment Station, Sungeo Buloh—The Secretary, London Advisory Committee for Rubber Research (Ceylon and Malaya), Imperial Institute, London, S.W.7 (July 30).

READER IN THE DEPARTMENT OF ANTHROPOLOGY, and a READER IN THE DEPARTMENT OF PSYCHOLOGY—The Registrar, Rajshahi University, Rajshahi, East Pakistan, and the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (July 31).

RESEARCH ASSISTANT (with a good honours degree in physics and some research experience, preferably in low temperature physics) to work on the design and operation of a liquid hydrogen bubble chamber —The Head of the Department of Physics, Imperial College, London, S.W.7 (July 31).

LECTURER IN PHILOSOPHY at the University of New England, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 1).

LECTURER (with industrial and research experience) IN ENGINEERING—The Secretary, The University, Edinburgh (August 1).

SENIOR LECTURER IN BOTANY at the University of Sydney, Australia —The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Sydney, August 1).

LECTURER IN BACTERIOLOGY at the University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (August 2).

BIOCHEMIST (with an appropriate science degree or A.R.I.C.)—The Group Secretary, The Royal Infirmary, Bolton.

CHEMIST or METALLURGIST (with an honours degree in chemistry or metallurgy) to carry out research on high temperature slag–metal–gas reactions—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Reactions".

GEOLOGIST (with a first- or second-class honours degree of a British university in geology, preferably with subsidiary geography) at the Ministry of Housing and Local Government in London, mainly to prepare memoranda on the distribution throughout the country of minerals of economic importance—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting G.206/5A (July 23).

LECTURER (Grade B) IN GENERAL SCIENCE in the Department of Hygiene and Public Health—The Clerk to the Governing Body, Battersea Polytechnic, London, S.W.11.

LECTURER IN EDUCATION to specialize in the teaching of psychology —Prof. E. A. Peel, Education Department, The University, Birmingham 15.

LECTURER (with a degree or A.M.I.Mech.E., or higher national certificate) IN MECHANICAL ENGINEERING—The Principal, Faraday House College, Southampton Row, London, W.C.1.

NUFFIELD RESEARCH FELLOW IN THE DEPARTMENT OF ZOOLOGY, to work on reagents which will increase contrast in electron microscopy of biological objects—Prof. J. F. Danielli, King's College, London, W.C.2.

PHYSICAL CHEMIST, Experimental Officer grade (preferably with a pass degree in chemistry, or at least H.S.C. (science) or equivalent), to assist in a group engaged in the production and filling of initiation explosives and to undertake development work in this field—Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 666/WOE/34.

PHYSICAL CHEMIST, Scientific Officer grade, IN THE PEDOLOGY DEPARTMENT, for work on ageing of oxides and the synthesis of clay minerals—The Secretary, Rothamsted Experimental Station, Harpenden, Herts, quoting "107".

PHYSICIST (male, with a good honours degree or A.Inst.P.) for research on servo control mechanisms—The Wool Industries Research Association, Torridon, Headingley, Leeds 6.

SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics or electrical engineering, or equivalent) at a Royal Air Force Station near Maidenhead, Berks, for operational research duties, theoretical studies and development work in the field of communications and general electronics—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.113/5A.

SENIOR EXPERIMENTAL OFFICER (with at least H.S.C. in science subjects or equivalent qualifications, and with considerable experience of electronics and solid state physics), for research on the solid state with particular reference to the application of magnetic resonance techniques—The Establishment Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 2/103/334.

SENIOR EXPERIMENTAL OFFICERS and EXPERIMENTAL OFFICERS (with at least H.S.C. in science subjects or equivalent qualifications, and with training in radio, electronics or physics, and preferably several years experience in the design and development of electronic equipment) IN THE GEOLOGICAL INSTRUMENT GROUP, for duties concerned with the design, development and servicing of electronic radiation measuring equipment for use in geological prospecting for radioactive minerals—The Establishment Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting 2/103/333.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Modern Solders. Third edition. Pp. 22. (Hemel Hempstead : Multicore Solders, Ltd., 1955.) [55

British Electrical and Allied Industries Research Association. Thirty-Fourth Annual Report, 1st January, 1954, to 31st December, 1954. Pp. 154. (Leatherhead : British Electrical and Allied Industries Research Association, 1955.) [55

West of Scotland Agricultural College. Bulletin No. 153 : The Establishment of Grass Seeds in South West Scotland. By I. V. Hunt. Pp. 16. (Glasgow : West of Scotland Agricultural College, 1955.) 1*s*. [55

Polarography with Tinsley Polarographs. (Instruction Book No. ETP 460.) Pp. 20. (London : Evershed and Vignoles Limited, 1955.) [55

Mushroom Research Association Limited. Final Report, 1954. Pp. 36. (Yaxley, Peterborough : Mushroom Research Association, Ltd., 1955. 5*s*. Distributed by the M.G.A., 45 Bedford Square, London, W.C.1.) [105

John Innes Leaflet No. 14 : Balanced Steaming of Glasshouse Soil. Pp. 8. (Edinburgh and London : Oliver and Boyd, Ltd., 1955. 1*s*. Published for the John Innes Horticultural Institution.) [105

Murphy Fruit Growers' Booklet, 1955. Pp. 92. (Wheathampstead : Murphy Chemical Company, Ltd., 1955.) [105

Lancashire Dynamo Holdings, Ltd., Report 1954. Pp. 12. (London : Lancashire Dynamo Holdings, Ltd., 1955.) [105

Report of the Rugby School Natural History Society for the year 1954. Pp. 28. (Rugby : George Over, Ltd., 1955.) [115

Department of Scientific and Industrial Research. Report of the Building Research Board, with the Report of the Director of Building Research for the year 1954. Pp. iv+72+12 plates. (London : H.M. Stationery Office, 1955.) 4*s*. net. [115

Discovery Reports. (Issued by the National Institute of Oceanography.) Vol. 27 : The Distribution of *Sagitta Gazellae* Ritter-Zahony. By P. M. David. Pp. 235–278+plate 13. (Cambridge : At the University Press, 1955.) 15*s*. net. [115

Department of Scientific and Industrial Research. Report of the Radio Research Board, with the Report of the Director of Radio Research for the year 1954. Pp. iv+48+2 plates. (London: H.M. Stationery Office, 1955.) 2s. 6d. net. [165

Ministry of Agriculture and Fisheries. Fishery Investigations. Series 2, Vol. 18, No. 9: Estimation of Growth and Mortality in Commercial Fish Populations. By J. A. Gulland. Pp. 46. (London: H.M. Stationery Office, 1955.) 6s. net. [165

Wye College (University of London). Report on Hop Picking by Machine. By G. P. Chater and Miss C. L. Jary. Pp. 26. (Wye, Ashford: Wye College, 1955.) 1s. [165

Forty-second Annual Report of the University of Leeds for the Academic year 1952–1953. Pp. 100. Forty-third Annual Report of the University of Leeds for the Academic year 1953–1954. Pp. 91. (Leeds: The University, 1953 and 1955.) [165

The Registrar General's Statistical Review of England and Wales for the year 1953. Tables, Part 2, Civil. Pp. viii+174. (London: H.M. Stationery Office, 1955.) 5s. net. [165

Ministry of Agriculture and Fisheries. Bulletin No. 123: Diseases of Vegetables. By Lawrence Ogilvie. Fourth edition. Pp. iv+80+12 plates. (London: H.M. Stationery Office, 1954.) 4s. net. [165

British Drug Houses Limited. Report and Accounts, 1954. Pp. 12. (London: British Drug Houses Limited, 1955.) [165

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